"The market potential for fish roe products in the Irish seafood industry"

Submitted in fulfilment of the requirements for a Masters of Business.

To
HETAC - *Higher Education and Training Awards Council*
2007

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Dedication

To the men in my life,

My wonderful sons,

Dáire and Eóin

Declaration.

I hereby declare that the work presented in this thesis is the result of my own research and has not been used previously to obtain a qualification in this Institute of Technology or elsewhere.

Signed; 

Acronyms

BIM	Bord Iascaigh Mhara
CFP	Central fund of Canada Ltd.
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
EPA	Environmental Protection Agency
EU	European community
FDA	Food and Drug administration
HACCP	Hazard analysis critical control points
HHP	High hydrostatic pressure processing
HPP	High Pressure Processing
ICES	International council for exploration of the sea
JETRO	Japan External trade organisation
MAP	Modified atmosphere packaging
NDP	National Development Plan.
TACs	Total allowable catches
TRAFFIC	The wildlife trade monitoring network
UHP	Ultra High Pressure

Acknowledgements

For inspiration and encouragement, a sincere thanks to Ms Evelyn Moylan and Dr Pauline King. You have made my journey even more rewarding and enjoyable. Special thanks must be extended to Dr Ronan Gormley for agreeing to be part of this research endeavour.

This research developed further links between the GMIT and Industry. Two truly innovative and inspiring men assisted greatly with this project. To Mr John Murphy, Fastnet Mussels Ltd and Mr Bill Carty of Cloonacool Arctic Char I extend my sincere gratitude. Many other industry professionals played a vital role in the work by completing questionnaires and generally imparting information. This demonstrates a strong desire by industry towards research and development and for this great credit is deserving. Personnel at BIM and the Marine Institute were at all times helpful and supportive.

For the management and employees, both academic and support staff of the GMIT I would like to express my sincere appreciation for your support during my never-ending voyage for knowledge.

To my true friends, a special thank you for your support and encouragement throughout this passage in time,
And for those who created hurdles for which to jump, it has made me stronger!

Executive summary

- This research aimed to identify the market potential for Roe products in the Irish seafood industry. The Seafood Sector Development Strategy 2007 -2013 was established with a view to secure a sustainable and profitable Irish seafood sector and new product innovation was identified as one of the key factors for increasing revenue in the future.

- The area considered in this report was the development of new products based on fish roe. The Irish roe industry is underdeveloped at present. The global demand for roe products is high with a market value of $256 million of exported caviar and fish egg substitutes in 2006 (Parker and Lilly, 2006). The variety of roe products is vast and varies for each market ranging from high quality caviar to caviar substitute products derived from egg white (personal observation).

- A survey of current seafood producers was conducted to determine Ireland's past and current activity in this area and also to determine future interest in developing new products.

- A market analysis of the Japanese, the American and the European Community market was conducted to determine the preferred product and to identify what gaps existed. Demand and prices for caviar-type products remain relatively high (Table 8). Salmon caviar achieves the lowest price per kg of caviar-type products from a fish base and is declining which may indicate that there is an abundance of this type of product available (Table 9).

- A case study was conducted on Cloonacool arctic char to determine the developmental potential of roe based products. In this production unit the

projected output for the year (2007) amounted to 1 tonne with a market value of €200,000.

- Product concepts were proposed taking into consideration the driving forces within the industry and the necessary key success factors. Findings suggest that strategically, Japan is an excellent export destination due to the large volumes of roe imported and their preference for roe with no or low levels of processing. Currently roe is primarily imported frozen or floated in brine.

- Findings suggest that fragmentation within the industry may be a stumbling block for future producers. Strategic alliances or the development of a co-op type operation may be beneficial to getting produce to market. This may be achieved by using existing structures to promote new products.

- Overall findings suggest strong market potential for fish roe products in the Irish seafood industry with the potential of adding in excess of €8million revenue to the industry.

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1. The market potential for fish roe products in the Irish seafood industry

1.1 Introduction

The aim of the research was to identify the market potential for roe products in the Irish seafood industry. The Irish Seafood industry continues to make a vital contribution to the Irish economy. Overall, Irish exports of seafood products in 2005 amounted to 198,623 tonnes valued at €354 million, representing a decline in volume of 24% and value of 7% from the 2004 figures (Anon, 2006a). Export value for 2005 was down 19% on target (National Development Plan). This materialised through increased output from farmed salmon Salmo salar/ Oncorhynchus nerka and decreased landings at Irish ports (Anon, 2006a). The combined value of Irish domestic seafood sales and exports amounted to €702 million compared to €711 million in 2004. Ireland's national quotas are a primary cause of these reductions, with an overall decrease of 14% from 2004 (Anon, 2006a). The NDP plan outlines a focus on value added products and a stronger commitment in new product development as key features for future success in the Irish Seafood Industry.

The Seafood sector development strategy 2007 -2013 (Anon, 2006b) was established with a view to:

- Securing a sustainable and profitable Irish seafood sector.
- Examining the potential for innovation, product development and value enhancement of primary aquaculture production and shellfish, whitefish and pelagic fish landed into Ireland.
- Promoting the growth of a competitive, consumer orientated, market-led, added value seafood sector.

To achieve this the strategy is to maximise the possibilities for synergies with other sectors of the Irish food industry, in the areas of food research, innovation, product development and integrated marketing. Identified within the strategy document are the benefits of forward integration as pursued by Bantry Bay Seafood. The seafood sector development strategy 2007 -2013 supersedes the NDP 2000 -2006/ Seafood

Processing Measure which distributed €32 million to various projects, this programme was the main instrument of policy in promoting investment in seafood processing. The NDP 2000-2006 provided exchequer grants to support capital investment for industry led initiatives. It was designed to develop the capability and efficiency of processing firms with the potential to increase the value of their output on a cost effective basis to secure market advantage, with strong focus on value added products for the seafood industry and new product development (Url, 1).

The global roe industry is worth $256 million of exported caviar and fish egg substitutes in 2006 (Parker and Lilly, 2006), Europe was responsible for 47.21% of exports. Ireland ranked 31st in this league table, with projected exports worth $257,000, which comprised of herring and cod roe all destined for the United Kingdom. "(Parker and Lilly, 2006). There was no further break down of these exports and little published evidence exists to further determine varieties of roe currently being exported.
This indicated that little roe is harvested in the Irish seafood sector, and there may be potential to develop new products which will further add value to the Irish seafood market.

1.2 Aims and objectives of research

The overall aim of this project was to support the Irish seafood industry, by identifying areas for further sustainable development and increasing revenue through value added products. Un-harvested roe from fish landed to Irish ports and the aquaculture industry have the potential to assist in achieving these goals. The aims and objectives of this research were to investigate the market potential for fish roe products in the Irish seafood industry. To realise this aim research was conducted as follows:

- The world market for caviar and fish roe products was described and analysed.

- The varieties of roe products available in leading markets within the caviar and roe industry was explored and their historical consumption investigated.

- The current driving forces in the Irish seafood industry were analysed, identifying the specific factors causing fundamental industry and competitive change.

- An overview on existing and potential markets for Irish roe was provided.

- The availability of roe within the Irish seafood industry was estimated.

- A questionnaire was circulated to Irish based seafood producers to enable the researcher to identify the activity in the areas of new product development, past and current production of roe products, and determine interest in future product development.

- Suitable fish species landed or cultured within Irish waters which provide roe with commercial potential were identified.

- New products were identified which will add value to the seafood market, generate a financial return for investors and fulfil the requirements of identified market gaps.

2 Research Methodology

2.1 Introduction

Research may be defined as any organised enquiry that is carried out in order to provide information that can be used to solve problems (O Sullivan *et al.*, 1996). Business research is a systematic enquiry that provides information to guide business decisions (Blumberg *et al,* 2005). This includes reporting, descriptive, explanatory and predictive studies (Graziano *et al*, 1997, Grix, 2004).
In this chapter research methodologies utilised are outlined in an endeavour to achieve prescribed objectives.

2.2 Research design

Research design is a framework for conducting the research project (Bell, 1995). It specifies the details of the procedures necessary for obtaining the information needed (Malhorta, 1996). The principle of triangulation (tripartide discussion) will be utilised, employing secondary and primary research, both qualitative and quantitative (Bell, 1995).

2.3 Secondary research

Initially, secondary research was conducted to determine the extent of current research and information available. This was achieved by researching previous research reports, newspaper, magazine and journal content, and government and industry statistics, publications, seminars, conferences and internet articles. BIM and the Marine Institute web site and library were utilised. Due to the nature of the subject there are few books available. However Meredith B. Gordon's (2002) and Igna Saffron (2002) publications portray a wealth of knowledge on the historical events of caviar. In contrast national and international seafood reports are in abundance due to the dynamic nature of the seafood industry and today's market place. *"Sea Change" – A Marine Knowledge, Research and Innovation Strategy for Ireland* 2007-2013 (Anon, 2006b) provides a clear and realistic picture of future opportunities and challenges and a roadmap for selective and managed investment in marine research and innovation.

CITES was used as a resource to put into context the value of our natural resources and the importance of protecting them.

To develop an understanding of new product development, diverse markets and current focus in the Irish seafood industry seminars were attended. These included:

- ***Introduction to New Product Development***: To gain an insight into the product development process at University College Cork (UCC), presented by Dr. Joe Bogue and Dr. Alan Kelly.
- ***Marine Functional Foods workshop*** at the Marine Institute, Oranmore, with presentations from Dr Peter Heffernan, CEO Marine Institute; Mr Barry Mc Sweeney, research co-ordinator with the Department of Communications, Marine and Natural Resources; Dr Colin Barrow, Vice president of research – Ocean Nutrition Canada; Dr Colin Dunne, research director with Glanbia Plc; Prof. Fereidoon Shahidi, memorial university Canada and Prof Bjorn Bjornsson Goteborg university Sweden
- ***Developing the Research Agenda*** at the GMIT, presented by Professor Tom Baum University of Strathclyde and Dr Noel Harvey GMIT.
- ***"Business opportunities in Japan",*** a seminar hosted by Enterprise Ireland in collaboration with Chambers Ireland, Irish exporters association and Ireland Japan association. This seminar outlined the pros and cons of entering the Japanese market, the resources required and the focuse on the key success factors for positive entry.

Through BIM, a report, which projects the market value of roe annually was procured. ***The World Market for Caviar and Fish Egg Substitutes: a 2006 Global World Perspective***, (Parker and Lilly, 2006) was utilised, in an endeavour to ascertain the current status of global trade for roe.

The International Council for the Exploration of the Sea (ICES), the organisation that coordinates and promotes marine research in the North Atlantic provided valuable information on catches recorded by Irish fishing vessels. This was a key element in projecting the available roe to market.

2.4 Primary research

The basis of primary research lies in descriptive, explanatory and predictive research (Blumberg *et al*, 2005). Techniques utilised included both qualitative and quantitative research (Creswell, 2003).

Qualitative techniques adapted for the purpose of this research included in depth interviewing, elite or expert interviewing and participant observation.
In depth interviews were conducted with industry participants to determine their interest in pursuing a particular product range and to determine their strategy for diversification or forward integration. Expert interviews were conducted with participants in the global industry to determine current trends and also market viability. Participation observation was conducted at the four major wholesale outlets globally for roe and seafood marketing. These were the Boston Seafood Show in USA, the Tskiji Market in Japan, the Mediterranean Seafood Show in Rimini, Italy and the European Seafood Exposition in Brussels.

Quantitative research was conducted in the form of an industry survey.
This industry survey was conducted to determine past and current activity in the roe industry. An important element to the survey was to determine future interest in new product development and also identify interested parties in diversification or forward integration. Deciding on the sampling frame was therefore simple. A survey was conducted on all the seafood companies registered with BIM, and structured question formats were used (Brace, 2004).

New product development process was also utilised as a form of primary research. For the purpose of this research new product development following the model identified by Armstrong and Kotler (2005) was used and shall be employed to concept stage. The stages followed included:

1. Idea generation
2. Idea screening
3. Feasibility
4. Concept development

The focus of this research was to develop products to concept stage. This can be a vital resource to the broad seafood industry in Ireland. Taking the new product development process further would be more specific, single product and single company focused.

2.5 New Product Development

A product is anything that can be offered to a market for attention, acquisition, use or consumption that might satisfy a want or a need. It includes physical objects, services, places, organisations and ideas (Kotler *et al*, 2003). There is little consensus as to what actually constitutes a new product. Fuller (1994) and Rogan (2003) believes a broad definition is the most useful and should encompass both the development and introduction of a product not previously manufactured by a company, or the presentation of an old product into a new market.

2.6 Innovation

According to surveys by Booz *et al.*, (1976, 1982), more than 90% of top managers at companies in such fields as aerospace, automotive products, pharmaceuticals, and telecommunications cite innovation in their products as absolutely critical to achieving their strategic objectives (Dehoff *et al*, 2007). They define innovation as the process for defining and creating new products and services. While it takes on many forms, it generally encompasses activities in customer and market understanding, technology management, product planning and product development.

Hughes *et al* (1996) emphasise the difficulties of new product development and equate the process to "*trying to hit a moving target from atop of a runaway train*".
Competitors come and go, technological change occurs at an ever-increasing rate, customer wants and needs are constantly shifting, and a product's life cycle may be shorter than its development time. In such a fast-paced environment, product development must be transformed into a continuous, iterative, learning process focused on customer value (Hughes *et al*, 1996).
A new product was defined (Fuller, 2005) as

"a product not previously manufactured by a company and introduced by that company into its marketplace or the presentation by a company of an established product perhaps in a new form or into a new market not previously sold by that company"

2.7 New product categories

Very few new products are actually new to the world. Booz, *et al.* (1982) estimated that, only 10 percent of all new products introduced over five years were truly innovative or new to the world. They conducted a longitudinal study amongst a number of companies and, from the data collected, concluded that the majority of products launched by manufacturers could be aligned within one of six categories (Booz *et al*, 1982),

- New to the world products - 10%
- New product lines: new products that for the first time allow a company to enter an established market - 20%
- Additions to an existing product line or new products that supplement a company's established product lines - 26 %
- Improvements or revisions to existing products: new products that provide improved performance or greater perceived value, and replaced existing products - 26 %
- Repositioning of existing products that are targeted to new markets or market segments - 7 %
- Cost reduction: new products that provide similar performance at lower cost -. 11%.

There are many varying definitions or classifications of a new product. Fuller (2005) classifies these as follows:

- Line extensions- a variant of an established product
- Repositioning of existing products, e.g. find an alternative use for an existing product.
- Reformulation of existing product, e.g. improved colour flavour, fibre content, new legislation, difficulty in sourcing raw material or reformulation to lower unit cost.

- New packaging of existing products, e.g. to change package style, introduce new technologies such as modified atmosphere packaging or improve thermal conductivity.
- Innovative products. Innovation implies modification or change. Innovative products are generally referred to as products with major change.
- Creative products- a creative product denotes a product brought into existence. Fuller (2005) emphasised added costs and time in developing a truly new product. When creative products are successful, while they may have first move advantage they are also prone to copycat products.

Thomas (1993) defines new products as "*running the gamut from simple renovations to a strategy of incremental innovation that might eventually lead to a major breakthrough*".

2.8 New Product Development models

Like opinions and classifications there are many New Product Development models. A typical model for a new product development system was described as having seven major phases with seven identified review points (Anon, 2002, Anon, 2003, Kotler and Armstrong, 2005). Emphasis is placed on multifunctional activities, co-operation, and parallel processes where activities run concurrently within the seven phase model. Activities carried out in each phase are presented at a review meeting where a decision to go, not to go, hold or recycle is made. An action plan including a list of activities, responsibilities, budgets and time frame is prepared. A market focus is needed at every phase of the NPD to ensure that when the product reaches the market it has been refined and modified to take consumer, market and trade demands into account. However, not every project needs to go through every phase and review, and subsequently this model can be adapted to suit specific needs and circumstances. The seven phases are identified as,

- **Idea generation**: In the first of the seven phases, ideas, opportunities and market gaps based on consumer and trade research are identified. New ideas can be sourced from company personnel, consumers, competitors and through trade research (Anon, 2002, Anon, 2003, Kotler and Armstrong, 2005).

- **Idea screening** is the first review point in the NPD system. Only those ideas with the best chance of success in the market continue to the next phase(Anon, 2002, Anon, 2003, Kotler and Armstrong, 2005).

- **The feasibility phase** establishes if a new product is viable as judged by criteria such as market demand, profitability and if the product can be produced. The feasibility studies in the previous phase are assessed at the feasibility review. If a potential market opportunity is identified, the project proceeds to the next phase (Anon, 2002, Anon, 2003, Kotler and Armstrong, 2005).

- **The concept development phase** confirms the tentative findings from the feasibility studies. This usually requires producing kitchen scale samples, which are used to establish if the target consumer is interested and if the trade is willing to list the finished product. At the concept review, it is decided if the project is still worth pursing based on the information available (Anon, 2002, Anon, 2003, Kotler and Armstrong, 2005).

- **The business phase** is critical, as it requires a detailed assessment of market, sales, production, technical, human resources and financial issues. At this phase, it is recommended that consumer research be conducted to evaluate reaction to the product concept in relation to the flavour, packaging, brand name, proposed price point, pack size, etc. Once the concept has been revised based on the findings of the consumer research, the concept should be presented to the trade for comment and feedback. Simultaneously, the company should conduct a detailed financial and technical assessment to ensure the product can be produced profitably and safely. The business case prepared is then assessed in the business case review. This is the last opportunity to end a project before the product development phase, a phase that can be time consuming and expensive (Anon, 2002, Anon, 2003, Kotler and Armstrong, 2005).

- **Further Development**: In the next phase, further development, the company should engage in full-scale development, including plant trials. All likely costs need to be taken into consideration including promotional spend, packaging and ingredients costs, trial and full-scale production costs. This phase can include test marketing the product to find out consumer reaction before full production commences. Before entering the launch phase, the project must pass a post development review. This ensures the project is still in line with company strategies and objectives (Anon, 2002, Anon, 2003, Kotler and Armstrong, 2005).

- **The launch phase** introduces the new product to the market. First production runs are initiated and market entry occurs. An informal review immediately follows the first production runs to ensure that the launch proceeded to plan. Following the launch, product, project and team performance is monitored. After an agreed time frame, usually 6 to 12 months after launch, the NPD team review product, project and team performances. The outcome of the final review is a decision to continue making the product or to remove it from the market (Anon, 2002, Anon, 2003, Kotler and Armstrong, 2005).

Other models identified include Holmes (cited by Fuller 2005). The stages emphasized here are, Company objectives, Exploration, Screening, Business analysis, Development, Testing, Commercialisation, Product success. More recent are Graf and Saguy (1991) who identify 5 major stages. These include screening feasibility, development, commercialisation and maintenance. Skarra (1998) developed a model identifying the major steps as assessing management commitment, finding the right idea, developing the business case, development and commercialisation.
Most authors agree that new product development can be divided into several phases. However Fuller (2005) highlights that the phases do not start, proceed and then finishes as the next phase begins. The phases are not strictly speaking sequential: they often overlap and are concurrent. Projects might even return to the conceptual stage for

3 Caviar and fish roe products

3.1 Fish roe and Caviar

Larousse gastronomique (Montagne, 2001) defines roe as the reproductive glands of male or female fish, containing the sperm and eggs respectively. The sperm or milt of male fish is referred to as soft roe. It is a soft white smooth substance which is rich in phosphorous. Milt is usually cooked in a court boullion or grilled. Caviar is defined as the fresh or salted roe of sturgeon. FDA (Food and Drug Administration) have restricted the name "caviar" to the eggs of the Sturgeon and state that any other caviar type product may carry the name caviar but only if proceeded by the name of the fish from which the eggs have been harvested. Caviars are made from fish roe after the eggs have been graded, sorted, singled-out, salted or brined, and cured (Bledsoe *et al*, 2003, Hui, 2006). Whole skeins of roe may be grilled and eaten or alternatively cured or smoked (Montagne, 2001)

Fish roe products are extremely valuable and currently enjoy expanding international and domestic markets (Nettleton, 1985). Caviars represent the best-known form of fish roe products; however, several other product forms are also consumed, including whole skeins and formulations with oils and cheese bases.

3.2 Nutritional content of fish roe and caviar

Fish roe are highly nutritious and a single portion of roe contains the following nutrients (Holland *et al*, 1991).

Table 1 Nutritional content of roe per single serving, 16g (Holland et al, 1991)

Nutrition Facts	
Serving Size: 16.0 g	
Calories 40	
Calories from Fat 26	
Amount per serving	% Recommended daily allowance. RDA
	Amount per serving
Total Fat 2.9g	4%
Saturated Fat 0.6g	3%
Monounsaturated Fat 0.7g	
Polyunsaturated Fat 1.2g	
Cholesterol 94mg	31%
Sodium 240mg	10%
Potassium 29mg	1%
Total Carbohydrate 0.6g	0%
Dietary Fiber 0g	0%
Protein 3.94g	8%
Vitamin A	6%
Calcium	44%
Iron	11%
Vitamin D	9.28%
Vitamin E	3.73mg
Thiamin (B1)	0.03mg
Riboflavin (B2)	0.099mg
Niacin (B3)	0.019mg
Vitamin B6	2.55mg
Vitamin B12	53.3%
Phosphorus	57mg
Magnesium	48mg
Panthothenic Acid	0.56mg
Zinc	1%
Manganese	0.008mg

Fat	65.2%
Protein	39.4%
Carbohydrate	6.0%

Fish roe contains 250 calories per 100g, 60% of which comes from fat. Fish roe while high in cholesterol contains high levels of omega 3 and vitamin b12. One serving of fish roe (16g) can also account for 44% of the recommended daily allowance (RDA) calcium 10% of RDA of vitamin D and 10% RDA of Iron.

Holland *et al* (1991) highlights the potential for fish roe to be marketed as a functional food due to its high level of vitamin B12 and omega oils. Vitamin B12's primary functions are in the formation of red blood cells and the maintenance of a healthy nervous system (Rogers, 1990). B12 is necessary for the rapid synthesis of DNA during cell division. This is especially important in tissues where cells are dividing rapidly, particularly the bone marrow tissues responsible for red blood cell formation (Cohen, 1981). Omega-3 fatty acids are considered essential fatty acids. They are essential to human health but cannot be manufactured by the body. For this reason, omega-3 fatty acids must be obtained from food. Clinical studies suggest that omega-3 fatty acids may be helpful in treating a variety of health conditions (Bender, 2005). The evidence is strongest for heart disease and problems that contribute to heart disease, but the range of possible uses for omega-3 fatty acids include obesity (Dangardt *et al* 2008), high cholesterol, high blood pressure (Engler *et al.*, 1999), depression (Feart *et al.*, 2008) and cancer prevention (Hall *et al.*, 2008) . Studies are also conducted into the use of omega 3 for the treatment of Attention Defecit Disorder and Attention Defecit Hyperactivity disorder (Gadoth, 2008, Vaisman, *et al.*, 2008). While all fish roe is relatively high in cholesterol, Falch *et al.*, (2006), identifies a higher level of cholesterol in roe than milt. Scano *et al.,* (2008), Rodgers (1990) and Bender (2005) all agree that there are many nutritional benefits to consuming fish oils.

3.3 History of Caviar

The popularity of caviar is not a new phenomenon. The commodity dates back to ancient times and has been prized in almost every culture across the globe (Gordon 2002). Sturgeon, the fish whose roe alone under Food and Drug Administration (FDA) in the United States (US) rulings may be classified as caviar, is a prehistoric fish that has been around for 250 million years, surviving since the time of, and outlasting, the

dinosaurs. Fossil remains dating from that time have been found on the Baltic coast and elsewhere (Saffron, 2002). Sturgeon are anadromous fish, meaning that they live in saltwater but return to freshwater to spawn. Twenty-four major species of sturgeon still exist, living mainly in the Caspian Sea, although their numbers have been negatively affected by pollution and over-fishing. Sturgeon can live to be over 100 years old and can grow to weigh over 3,000 pounds (Saffron, 2002).

References to caviar in literature and art date back almost as far as the sturgeon itself. It has been suggested that by 2400 B.C. ancient coastal Egyptians and Phoenicians had learned to salt and pickle fish eggs to make them last through war, famine or trips at sea (Gordon, 2002). According to Aristotle (cited by Gordon, 2002), the ancient Greeks were no strangers to caviar either, as "lavish Greek banquets would end with trumpet fanfare announcing the arrival of heaping platters of caviar garnished with flowers. Some claim it was the Turkish who first coined the word "khavyar" from which the English term "caviar" originates. Others suggest the term "caviar" comes from the Persian word "chav-jar" which translates loosely to "cake of power" or "piece of power." In the 1240s the first written record of the word "khavyar" was found in the writings of Batu Khan (grandson of Ghengis Khan), while the word first appeared in English print in 1591 (Saffron, 2002).

By the middle ages many countries' sovereigns had claimed the rights to sturgeon. In Russia, China, Denmark, and France, as well as in England, "fishermen had to offer the catch to the sovereign, often for fixed rewards. In Russia and Hungary, the sections of rivers considered suitable for fishing the great sturgeon were the subject of special royal grants (Saffron, 2002).

Caviar was enjoyed in France as early as 1553 according to Rabelais in his work *Faits et dits Heroiques du Grand Pantagruet* (1553). Meanwhile, the *Larousse Gastronomique cites la Dictionnaire du Commerce* (Montagne, 2001), mentioned the dish as well: "*kavia* is beginning to be known in France where it is not despised at the best tables". As the main consumers of caviar in Russia, the czars levied a caviar tax on sturgeon fishermen. It is said that Nicholas II was given eleven tons of the finest caviar each year by his fisherman subjects (Saffron, 2002).

Before over-fishing in the "new world" almost obliterated their stock of sturgeon as well, many American states also produced caviar by the end of the 19th century. Until 1900 the United States produced about 150,000 pounds of caviar per year. Most of this

domestic caviar came from the Delaware River at Penns Gover, New Jersey. At one time, Hudson River sturgeon were so plentiful that their flesh was referred to as "Albany beef" (Saffron, 2002).

This led to fraud, as during the "caviar boom" at the end of the nineteenth century, "much of the American caviar harvest shipped to Europe was imported right back to the United States again, labelled as the more coveted Russian caviar". In 1900, the state of Pennsylvania issued a report, which estimated that ninety percent of the Russian caviar sold in Europe actually came from the US (Url, 14)

The demise of caviar began with the fall of the Russian empire. In 1990 Russia produced three times more caviar than Iran but by 1996 Russian output was down to 82 tonnes compared to Iran's 286 tonnes (Saffron, 2002). The environmental group TRAFFIC, the wildlife trade-monitoring network suggested that the Russian catch only accounted for 10% of the actual catch. Saffron (2002) states that around the same time as the poachers increased their catches the hatcheries which assisted nature in restocking the Caspian Sea began to close due to lack of investment. This over harvesting coupled with increased pollution contributed to continued decline over the following years to date. Iran was far more proactive in restocking and therefore protecting its industry (De Meulenaer and Raymakers, 1996). CITES currently control closely the trade of caviar and in 2006 refused to publish quotas for countries in the former Russian republic until these countries put strategies in place to protect their stock (Url, 2). America used this restriction to their advantage to promote their aquaculture, promoting their home product as sustainable and appealing to the ethical customer. Global demand remains high in the face of declining stocks (Gordon, 2002). The greatest concerns facing the global industry today are conservation and pollution (Anon, 2003).

With a declining supply and strong demand for this product, many other similar products have been brought to market, namely salmon and trout caviar and other fish roe caviars made to simulate the original product (personal observation).

3.4 Production of caviar and fish roe products.

Just as there are many roe varieties on the market there are many processing methods utilised in their production. The following is a summation of production methods most commonly employed for the preservation of caviar and roe products.

3.4.1 Chilling and Freezing

Chilling and freezing are common methods of preservation and in the case of a perishable food such as fish roe, strict Hazzard Analysis Critical Control Points (HACCP) regulations are applied at all times (Altug and Bayrak, 2003). The micro flora of the caviar is composed of micro organisms multiplying at 35°C, such as cocci, coli-like bacteria, yeasts and moulds. These micro organisms arise from the flora of the fish and can be transmitted to fish roes in the course of processing and can affect the product in a negative way due to the lack of hygiene and sanitation in the course of caviar production (Brunner *et al,* 1995, cited in Altug and Bayrak, 2003). Over 60% of unprocessed fish roe exported from US to Japan is frozen. This facilitates the logistics of time delay and bacterial deterioration, thus ensuring prime product arriving in Japan for processing. Long term freezing can effect both the sensory quality and colour of fish products (Hamre *et al.*, 2003). The new development of smart packaging also facilitates security of fish products in transit (Diamond, 2007) Freezing is a relatively inexpensive method of preservation with low levels of fixed asset investment requirement.

3.4.2 Salting/ brining / pickling/ marinating

Salting is the preservation of food using salt. This is an age old method of preservation as salt deprives bacteria, fungi and other dangerous pathogens of their biological requirements for life (Leto and Bode, 1985). Living cells in high concentration of salt are dehydrated through osmosis and become inactive. Salt prevents the oxidation of fatty acids in the fish roe (Espe *et al.*, 2002, Hamre et al., 2003, Caprino *et al.*, 2008). Prior to the smoking process, food is also salted to prevent bacterial growth (Porsby *et al.*, 2008). Traditional Caviar is produced using the salting method.

3.4.2.1 Caviar production

The production of caviar from sturgeon eggs can be a complicated and delicate matter, refined over years and trusted to the most accomplished experts (Saffron, 2002). However, the first parts of the process were traditionally barbaric. The sturgeon were caught in large nets, and guided to shore by boats and winches. Mature, female sturgeon were stunned by a blow to the head with a wooden club, taken on shore, and stunned again. An incision was made in the belly of the sturgeon, and the whole egg sack removed. In Russia, the sack was removed before the fish died and in Iran, the fish were killed before the sack was removed (Saffron, 2002).

The egg sack was placed on a wire sieve, used to separate the berries of different sizes. Once they were rinsed, the berries were classified by size and colour, and salted by a Master Salt Blender. The best berries are treated as *malossol* meaning literally "little salt" – not more than five percent by weight of salt is added to these eggs.

The salt both acts as a preservative and also helps to cure and make the berries firmer, which when raw have almost no texture at all. Kaitaranta (2006) identifies the difficulties with the storage of fresh roe, due to the high lipid content the roe may become rancid in a short period of storage. Iranian caviar producers add borax to the mix, to give the caviar a softer and sweeter finish (Altug and Bayrak, 2003). Sodium borate is used as a food additive in some countries with the E number *E285*, but is banned in the United States. Its use is similar to salt, and it appears notably in French and Iranian caviar In 2000 the FDA made a seemingly unofficial decision to allow caviar with borax into the country, despite its reluctance to remove the additive from the list of no permitted food additives (Lewis, 2002). After salting the excess liquid is removed and the caviar is packaged and ready for distributed.

Pickling is a method of preserving food by placing it or cooking it in a substance that inhibits or kills bacteria and other micro-organisms (Honikel, 2008). This material must also be fit for human consumption. Typical pickling agents include brine (salt solution). Floating food in brine to preserve its delicate surface is a common practice with fish roe, in particular salmon and trout roe. Stodolnik *et al.*, (2006) investigates the use of salt solution in the preservation of both freshness and structure of trout roe. Marinating involves storing foods in solutions such as vinegar Smoking and drying Smoking and drying are more conventional methods of preservation and have stood the test of time. Smoking is the process of flavoring, cooking, or preserving food by

exposing it to the smoke from burning or smoldering plant materials, most often wood (Leto and Bode, 1985). Meats and fish are the most common smoked foods. "Hot smoking" is a several-hours-long process that can be used to fully cook meats or fish: barbeque is a form of hot smoking. "Cold smoking" is an hours- or days-long process in which smoke is passed over the food which is held in a separate area from the fire. Generally the food is held at room temperatures (15–25.5°C/60–80°F) as it is smoked. since no cooking takes place, the interior texture of the food is not affected: neither are any microbes living within the meat or fish. For this reason, cold-smoking has traditionally been combined with salt-curing, in such foods as ham, bacon, and cold-smoked fish like smoked salmon. Smoked salmon caviar is available on the market This process may also be used for other roe. This involves light salting and smoking. The product is then frozen for further distribution.

Salting and drying of roe is commonly used in the production of Bottarga (Scano *et al.*, 2008), which is often referred to as Sardinian Caviar. Salting or curing draws moisture from the meat through the process of osmosis. Drying of food is one of the oldest methods of food preservation, which reduces water activity sufficient to delay or prevent bacterial growth (Leto and Bode, 1985)

3.4.3 Pasteurisation and pressing

Alternate methods of caviar production include pasteurisation and pressing. Some experts in the field have opposed the pasteurisation process, saying that it negatively and drastically changes the flavour of the finished caviar (Saffron, 2002). Pressed caviar or *pajusnaya*, is another alternative method of caviar production used for overly mature or broken eggs. A thick, salty, marmalade-consistency spread, it is made by gathering the broken or otherwise undesirable eggs in a cheesecloth sack, compressing the sack from all sides, and draining the excess liquid. While lacking the prestige of the more conventionally prepared caviar, this spread is less expensive, and is quite popular in Russia and Greece. New research has highlighted the potential for processing trout roe by pasteurisation (Miettinen *et al.*, 2005); extending shelf life to six months under refrigerated conditions. Pasteurisation is also used for many other caviar varieties.

3.4.4 High Pressure processing

High pressure processing (HPP) is another preservation method that may suit the delicate nature of the fish roe.

High Pressure Processing is a method of food processing where food is subjected to elevated pressures, with or without the addition of heat, to achieve microbial inactivation or to alter the food attributes in order to achieve consumer-desired qualities (Douglas, 2006, Villacis *et al.*, 2008). Pressure inactivates most vegetative bacteria at pressures above 60,000 pounds per square inch. HPP retains food quality, maintains natural freshness, and extends microbiological shelf life (Oey *et al.*, 2008). The process is also known as high hydrostatic pressure processing (HHP) and ultra high-pressure processing (UHP). Most processed foods today are heat treated to kill bacteria, which often diminishes product quality. HPP provides an alternative means of killing bacteria that can cause spoilage or food-borne disease without a loss of sensory quality or nutrients. Examples of high-pressure processed products commercially available in the United States include fruit smoothies, guacamole, ready meals with meat and vegetables, oysters, ham, chicken strips, fruit juices, and salsa (Flick, 2003, Villacis et al., 2008). HPP has found some niche markets with shellfish such as oysters, lobsters *Homarus americanus/Homarus gammarus* and mussels. This technology presents the unique possibility of easily extracting meat from their shells without need of knife or thermal treatment. As these provide a safe product to the consumer there is potential for increased margins being achieved. While shucked shellfish have the shelf life similar to that of a cooked product, the weight loss in conventional cooking methods does not exist in High pressure processing. This results in a higher perceived yield. No roe products are currently available on the market using this method.

Tests have shown that when the red and white muscle of fish are pressurised, the muscle tissue becomes opaque and takes on a cooked fish appearance, which may not always be desirable (Flick, 2003). High pressure Processing meets consumer demands for freshness without the negativity of often associated with other methods such as irradiation.

3.4.5 Low frequency radio waves

The use of low frequency radio waves is relatively new to the food industry. A new study on the effects of this method of food production illustrates the benefits achievable (Al Holy *et al.*, 2004). In this study, chum salmon caviar and sturgeon caviar were inoculated with three strains of *Listeria innocua* regarded as a contaminating bacteia. The results showed that the visual quality of the caviar products treated by radio frequency was comparable to the untreated control (Al-Holy *et al.*, 2004). *Listeria innocua*, cells and total mesophilic microorganisms were totally destroyed by the process. A mesophile is an organism that grows best in moderate temperature, neither too hot nor too cold, typically between 25 and 40 °C (77 and 104 °F). The term is mainly applied to microorganisms. This is key research as caviar is heat liabile, and conventional pasteurization processes negatively affect the texture, colour, and flavour of these foods (Al-Holy *et al.*, 2004).

3.5 Varieties of roe products available on the market

Of the twenty-four species of sturgeon existing worldwide today, only three types supply caviar: the Beluga *Huso Huso*, the oscetra *Acipenser sturio Acipenser sturio,* and the sevruga *cipenser stellatus*. To fill the void many other imitation types of caviar have appeared on the global market. The following is a synopsis of caviar and roe products available.

Table 2 Synopsis of roe products available on the global market

Common name	Scientific name	Form	Features	Scarcity	Price High/medium/ low
Beluga	*huso huso*	Salted/fresh, loose eggs	Light to dark in colour, large egg with visible eye, delicate skin.	Rare	High
Oscetra	*Acipenser sturio*	Salted/fresh, loose eggs	Dark brown to grey, unique flavour of hazelnuts, delicate skin.	Rare	High
Sevruga	*Acipenser stellatus*	Salted/fresh, loose eggs	Light to dark grey, small egg		High
Sterlet	*Acipenser ruthenus*	Salted/fresh, loose eggs	Small grained golden caviar	Very rare	High
Flying Fish	*Exocoetidae*	Salted, loose eggs	Crunchy orange eggs full of flavour. Often flavoured and coloured	Not rare	
Mullet	*Mugil cephalus*	Salted and dried, whole lobe	Sardinian caviar, entire roe sac is salted and dried	Not rare	Low
Tuna	*Thunnus*	Salted and dried, whole lobe	Sardinian caviar, entire roe sac is salted and dried	Not rare	Low
Capelin	*Mallotus villosus*	Salted loose eggs	Fluorescent orange coloured eggs	Not rare	Low
Lake whitefish	*Coregonus clupeaformis*	Salted loose eggs	Crunchy eggs which are flavoured and coloured	Not rare	Low
Herring	*Clupea harengus*	Salted loose eggs and whole lobes	Salted whole roe sac, or loose eggs salted (Avruga caviar)	Not rare	Low
American shad	*Alosa sapidissima*	Canned/ fresh in season, whole lobe	Dark brown in colour	Not rare	Low
Sea urchin	*Siphamia versicolor, Paracentrotus lividus. Psammechinus miliaris*	Fresh and salted	Red or yellow in colour, complete lobe is eaten.	Rare	High
Paddlefish	*Polyodon spathula*	Farmed. Salted.	Steel grey, glossy, buttery flavour	Not rare	Low
Hackleback	*Scaphirhynchus platorhynchus*	Fresh and salted	Glossy black, sweet nutty flavour, medium sized firm eggs	Rare	Medium
Bowfin	*Amia calva/ Abramis brama*	Farmed. Salted.	Small firm black eggs, tastes similar to sturgeon	Rare	Medium
Salmon	*Salmo salar/ Oncorhynchus nerka*	Salted, occasionally smoked	Golden orange to red colour, juicy large sized roe, intense salmon flavour	Not rare	Low
Trout	*Oncorhynchus mykiss*	Salted, pasteurised	Medium sized golden orange eggs	Not rare	Low
Lumpfish	*Cyclopterus lumpus*	Salted	Fine grained crunchy eggs which are usually coloured and flavoured	Not rare	Low
Cod	*Gadus morhua*	Salted and smoked paste, or cooked whole and eaten	Mild fish flavour, heavily salted	Not rare	Low
Pollock	*Theragra chalcogramma*	Salted and spiced whole lobes	Mild fish flavour, heavily salted and spiced	Not rare	Low
Lobster	*Homarus americanus, /Homarus gammarus*	Salted or cooked	Shiny black when raw, red when cooked	Not rare	Low
Carp	*Cyprinus carpio*				
Mock caviar		Black pearls made from various protein bases (see appendix 1)	Black firm pearls	Not rare	Low
Seaweed roe		Vegetarian. Cholesterol free with long shelf life	Black firm pearls	Not rare	Low

3.5.1 Summary

It is apparent that there are many varieties of fish roe and fish roe products on the market, utilising various methods of preservation, resulting in a wide variety of wholesale and retail products. All of these must be considered when developing potential new products for the Irish seafood industry..

4 International Market Analysis (Macro)

4.1 Introduction

"The world Market for caviar and fish egg substitutes: a global perspective "is a report created annually for strategic planners and import and export managers who are concerned for this particular market (Parker and Lilly, 2006). With the globalisation of markets, the report gives an insight into the dispersion of trade and demand for these products. The report sets out to identify the various stakeholders, quantify the market monetary value of caviar and fish egg substitutes for caviar. It is important to note that they are not exact values but projected values based on historic events and other relevant information on the economic profile of the countries. The quantities projected are based on caviar and preserved fish egg substitutes for caviar, not untreated natural lobes of roe.

The total caviar and fish egg substitute exports for the year 2006 was projected at $256.131 million. The percentage of these exports are as follows, Europe 47%, North America 33%, The Middle East 12%, Asia 7% and Latin America, Africa and Oceana accounting for the final 1%.

The break down of projected sales in US $ by region is as follows:

Table 3 Projected exports of caviar and fish roe products in the global market for 2006 (Parker and Lilly, 2006)

Europe	$120,911,000
North America	$86,545,000
The Middle East	$30,053,000
Asia	$18,317,000
Latin America	$126,000
Africa	$119,000
Oceana	$60,000

The major importers as projected ((Parker and Lilly, 2006) are Europe 55%, Asia 34%, North America 8%, The Middle East 2% and Oceana, Latin America and Africa

accounting for the remaining 1%. The following data summarise the projected imports of caviar and fish egg substitutes by the various regions in US$;

Table 4 Projected imports of caviar and fish roe products in the global market for 2006 (Parker and Lilly, 2006)

Europe	$141,921,000
Asia	$85,860,000
North America	$20,505,000,
The middle east	$5,913,000
Oceana	$1,178,000
Latin America	$717,000
Africa	$37,000

Within each of these regions countries display varying degrees of import/export activity. The United States is projected as the top exporter, exporting in excess of $66 million, followed by Iran with projected exports of $28 million. A further breakdown of the top ten leading exporters are as follows.

Table 5 Top ten activists in exports of caviar and fish roe products globally, by percentage (Parker and Lilly, 2006)

United states	25.99%
Iran	11%
Sweden	8.46%
Iceland	8.41%
Germany	6.78%
Canada	5.21%
Denmark	5.14%
China	4.96%
Russia	4.36%
Norway	3.97%

Japan has projected imports of $75 million, Germany $32 million and France $31 million of the global caviar and fish egg substitutes industry. The following illustrates

the import activity of the top ten countries within the regions. The Data is represented as a percentage of the total projected world import trade of Caviar and fish egg substitutes.

Table 6 Top ten activists in imports of caviar and fish roe products globally, by percentage (Parker and Lilly, 2006)

Japan	29.11%
Germany	12.65%
France	12.26%
Sweden	8.52%
United States	7.20%
Denmark	5.22%
Spain	3.19%
South Korea	2.59%
Switzerland	2.07%
Belgium	1.85%

Based on the results of the above table the main players in the global caviar and fish egg substitute market are identified as being Japan, Europe and North America. These may be potential export destinations for future Irish products.

4.2 Market price index

Table 7 is an index of retail prices achieved for the various products expressed in Euro. Prices indicated are the mean calculation of three retail prices available on the internet on the 14th day of May 2007. Prices were converted to Euro on *xe.com,* a currency conversion web facility also on that date. There is a vast difference in the price of the various roe products, ranging from €546 per 100g of Osetra to €118 per 100g for Beluga Caviar and €5 per 100g for salmon roe and mock caviar based on seaweed.

Table 7 Retail selling price of various roe products available on the global market, per 100g (2007)

Product type	***$ per 100g***	***€ per 100g***
Beluga	160	118.20
Sevruga	80	59.10
Osetra	740	546.76
Paddlefish	100	73.88
Golden white fish caviar	27	19.94
Chum salmon caviar	20	14.77
Pike caviar	17.34	12.81
Hackleback	100.22	74.04
Paddlefish	86.35	63.79
Shovelnose	112.14	82.85
Spoonbill	97.50	70.03
Salmon	7.50	5.54
Protein	10.73	7.92
Trout	29.39	21.709
Herring	13.75	10.16
Lumpfish	8.06	5.95
Mullet roe (dried)	119.96	88.62
Seaweed caviar	6.99	5.17

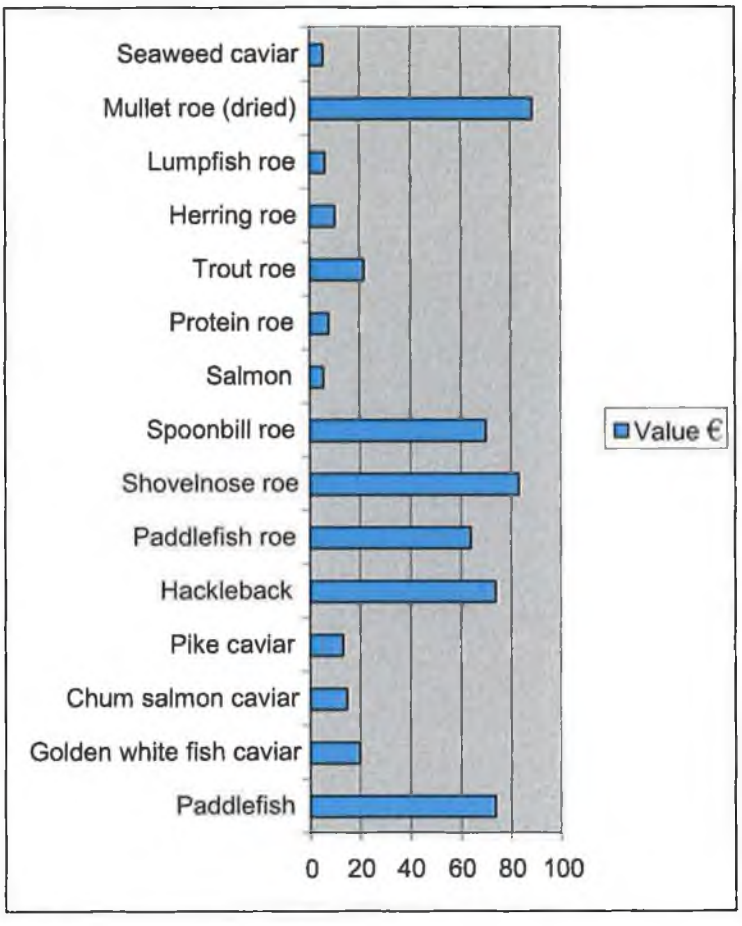


Fig. 2 Retail selling price of various roe products available on the global market, per 100g (2007)

4.3 Wholesale markets

4.3.1 Japan

Net trade flows indicate that Japans consumption of caviar and fish egg substitutes is highest, with the net trade flow projected for 2006 as $70,639,000 (Parker and Lilly, 2006). The majority of fish roe exported to Japan is first frozen. 61.1% of roe arrive in a frozen state and is then subject to processing. Salmon roe is an exception to this and is usually floated in brine to protect its delicate surface. Japan may prove a vital export destination for potential roe products harvested in Ireland.

The majority of roe products are transported to and sold from central fish markets. The largest and best known of these is the Tokyo central Wholesale Market. The Market is

more commonly known as the Tsukiji fish market and boasts being the largest wholesale fish and seafood market in the world.

Japan has a population of 127 million and boasts the second largest economy in the world. In 2004 Japan showed a GDP of $4689 billion, with a real GDP (Parker and Lilly, 2006) growth of 2.7%. Imports amounted to $598.3 billion, of which seafood ranked in the top ten imports (Parker and Lilly, 2006). Enterprise Ireland have identified that the Japanese market for foreign-made food and drink products has opened up rapidly in recent years, due both to the inability of domestic producers to satisfy internal demand, and as the tastes of Japanese consumers have become more internationalised. In particular Japan's current decline of seafood resources and the resultant declining domestic production, provides expanding export opportunities to Japan, which are supported by improved and developed distribution technologies in air transportation and freezing (Url, 6).

Enterprise Ireland have set up a regional office in Tokyo and offer support to companies wishing to enter the market.

4.3.2 The European Market

Europe another main player in roe import and export activity. Europe's projected imports for 2006 were $142 million with projected exports reaching $120 million (Parker and Lilly, 2006). The countries with the highest import activity are Germany and France. Germany, Sweden and Denmark combined are responsible for 20% of all exports.

The European Seafood Exposition (ESE) is the largest wholesale seafood event in the world. The exhibition boasts over 1600 exhibitors from more than 77 countries, ESE offers seafood business professionals access to a one-stop resource to reach global retail, foodservice and wholesale companies.

A competition is run each year to highlight the best new seafood products of year, the 2007 Seafood Prix d'Elite. The competition names the best new retail and foodservice products at the European Seafood Exposition and offers special awards for health and nutrition, retail packaging, originality, convenience and seafood product line. This provides a showcase for new products each year and exposure to a global market, which may be a vital resource in promoting new roe products.

The Mediterranean Seafood Exposition (MSE), the international show dedicated to Mediterranean Fishing Industry Technology and Produce is held annually in Rimini, Italy. Seafood production in all its forms is highlighted at the show, from fresh produce to preserved and gourmet seafood, as well as processing, preservation and transport technology.

In 2007, One hundred and seventy companies exhibited at the show of which sixty-two were from outside Italy (personal observation). The majority of exhibitors (49%) were involved in distribution with only 5.5% involved in production. 20% of exhibitors were involved in catering and food service sector. In an exit interview by MSE the following was outlined:

- 55.6% concluded business deals
- 52.6% updated on new products exhibited

This exhibition provides a vital resource for launching or selling Irish based roe products. BIM support Irish industries that wish to exhibit at the Mediterranean Seafood show by partially funding an exhibition area and assisting with networking (personal observation)

4.3.3 The North American market

The North American market differs greatly from the Japanese market with projected exports for caviar and fish roe products in 2006 of $120 Million, far exceeding imports of $20 million (Parker and Lilly, 2006). This reflects roe products and untreated natural roe. America has been very strategic in the protection and the promotion of their roe and caviar market. A ban on Russian caviar and a strong marketing strategy for American products is a key success factor of the industry (Goldburg *et al.*, 2001). A positive image is given to farmed sturgeon roe, as being environmentally friendly and protecting the natural habitats of wild fish (Grankvist *et al.*, 2007, Shaw and Shiu, 2003). North America recorded 51 million kg of fish roe exports in 2003 and 55 million kg in 2004. while there was an increase in the overall volume there was a slight decrease in overall value, reducing from 499 million in 2003 to $478 million in 2004. (Url, 7). There were noticeable decreases in price per kg of Pollock and herring and an increase in price per kg for salmon and mullet (Table 8).

Table 8 Caviar and roe products exported from US market 2003 and 2004. (Adapted from Url 7)

Product	Method of preservation	2003 (KG)	2003 Value $	$ Per kg	2004 (KG)	2004 Value $	$ Per kg
Atlantic pollock roe	Frozen	21,729,302	288,382,256	13.27	24,482,468	287,596,026	11.75
Salmon Roe	Frozen	11,018,028	82,782,185	7.51	8,047,135	64,995,407	8.08
Salmon Roe	Dried/salted/smoked	1,352,324	13,017,607	9.63	1,298,408	12,759,563	9.83
Herring roe	Frozen	4,151,094	11,925,252	2.87	7,547,048	11,504,670	1.52
Herring roe	Dried/salted/smoked	3,765,289	6,776,801	1.80	5,327,042	8,354,398	1.57
Sea urchin roe	Fresh/chilled	1,005,052	41,822,879	41.61	1,098,444	44,722,647	40.71
Mullet roe	Fresh/chilled	543,133	6,827,816	12.57	406,580	5,453,456	13.41
Mullet roe	Frozen	86,879	1,115,064	12.83			
Fish liver and roe	Frozen	5,496,514	27,833,591	5.06	5,169,587	29,804,023	5.77
Fish liver and roe	Dried/salted/smoked	380,745	4,279,308	11.24			
Fish liver and roe	Fresh/chilled	1,617,852	10,946,528	6.77	1,629,854	9,106,045	5.59
Caviar or caviar substitutes		273,963	4,004,820	14.62	321,469	4,243,721	13.20
Sturgeon roe	Frozen	6,456	66,795	10.35			
Total		51,426,631	499,780,902		55,328,035	478,539,956	

North America exports circa 1.3 million Kg of salmon roe, dried, smoked, salted or in brine each year, with a considerable price variance with each export destination. In 2005 Germany paid the premium $6.95 per lb ($15.29 per Kg) for salmon roe, dried smoked salted or in brine, and the lowest achieved price was $2.20 ($4.84 per Kg) for exports to Georgia and Italy. Japan imported in excess of $8.5 million worth of salmon roe (dried smoked salted or in brine) paying $4.26 per lb (Url, 7).

Table 9 North America exports of salmon roe, dried smoked salted or in brine, 2005. (Url, 7)

Export destination	Quantity Kg	Market Share %	Export value $ / lb	Export value $ / kg	Total value $ (000)	Total value € (000)
Japan	919,042	75.2	4.26	9.37	8,632,	5,521,
Israel	88,127	7.2	2.51	5.52	488,	312,
Germany	82,689	6.8	6.75	14.85	1,230,	787,
France	52,211	4.3	4.87	10.71	561,	358,
Georgia	46880	3.8	2.2	4.84	227	145,
New Zealand	10,020	0.8	7.24	15.92	160	102,
Italy	5,474	0.4	2.20	4.84	27	17,
Chile	4,771	0.4	2.50	5.5	26	17,
Dom Rep	2,725	0.2	4.95	10.89	30	19,
Other	10,545	0.9	6.67	14.67	155	99,

Japan accounts for 75% of the total exports of salmon roe, amounting to, in excess of $8.63 million.

Another major roe export segment is Pollock *Theragra chalcogramma* roe. United States export almost 27 million Kg of frozen Pollock roe each year with an estimated value of $329 million (Url, 7). The majority of the frozen Pollock roe is destined for Japan (60.9%), totalling in excess of $179 million. Korea (37.1% market share) imported $145 million of frozen Pollock roe paying a premium of $6.45 per lb, $1.61 per lb in excess of Japans unit cost.

The breakdown of the export market is as follows.

Table 10 North America exports of pollock roe (frozen) to global destinations, (Adapted from Url, 7)

Export destination	Quantity Kg	Market Share	Unit cost $ per lb	Unit cost $ per kg	Total value $ (000)	Total value €
Japan	16,792,028	60.9	4.84	10.68	179,347,	114,707,
Korea Rep	10,222,052	37.1	6.45	14.19	145,442,	93,022,
China	430,024	1.6	3.41	7.50	3,233,	2,067,
Estonia	78,520	0.3	4.00	8.80	692,	443,
Germany	25,582	0.1	2.95	6.49	166,	106,
Netherlands	25,000	0.1	2.72	5.98	150,	96,
Bahamas	3,705	0.0	1.26	2.77	10,	6,

The United States is a key player in the world roe industry with diverse markets for its produce. The market was worth in excess of $478 million with Japan accounting for approximately 70% of this (Url, 7). Prices vary greatly depending on destination markets and vary slightly from year to year.

4.4 Global Consumer trends

Several factors contribute to the changing trends in food consumption. Coyle *et al.*, (1998) outlines the most important of these as being the per capita income. As income grows there is a shift from the traditional food commodities eaten at home to more varied diverse foods. There is also a trend as developing nations become more time

poor and cash rich, of eating a higher percentage of meals outside of the home. Other factors affecting consumer trends and production trends within a country include factors of production, transport costs, and trade policy changes. Gehlhar (1998) summarises the changes: "For developing countries, consumption and trade are shifting from basic staples towards higher value livestock products and in high-income countries, demand for foreign brands are expanding intra-industry trade in processed consumer-ready products". Coyle *et al.*, (1998) highlights the relationship between income growth and protein consumption.

There are many factors which affect food consumption and generalisation is difficult. The following is an overview of identified trends both globally and in Ireland. Bord Bia was involved in world wide research aimed at identifying the main lifestyle trends shaping consumer thoughts, aspirations and buying patterns in the global marketplace (Anon, 2008). The research highlighted six key trends and examined the impact they are having on product introductions, brands, communications and activities. These trends identified included

- 'Life on the Go': consumers are looking for solutions to their busy life schedules and products and services that remove complexity and save time become essential elements in consumers' lives.
- 'Living life to the full': consumers want experiences that help them get the most out of life. Consumers are experimenting with new combinations and fusions are gaining the attentions of consumers seeking these new experiences.
- 'Making a difference': Demand is rising for products that have reduced their impact on the environment or that offer a sustainable alternative. This trend was emphasised at the Brussels Seafood Show 2007 with many companies claiming ethical and sustainable benefits to their products.
- 'The quest for health & wellness': managing health and well-being is a key concern for global consumers. This trend is very obvious with the vast array of products boasting health benefits.

- 'Smart shoppers': Consumers are becoming more educated and increasingly aware of the frills that are included in the price of products and services that they buy.
- 'The real thing': - In our increasingly commercialised and global marketplace, a growing number of people are looking for companies and products they feel they can trust. Consumers want to rediscover traditional and simple ways of doing things and are increasingly aware of traceability.

Macro trends identified by Baines (2006) that influence the taste and food eaten include

- **Healthier and lighter**: the stodgy foods of the past are no longer popular.
- **Flavour sensation**: customers want an explosion of taste in each bite.
- **Snacking and Grazing**: the breakdown of formal meals times is identified, the void being filled by convenience snacking.
- **Food and enjoyment**: people are more interested and more educated about food
- **Health Fads**: there are an increasing number of fad diets, which is forming part of today's culture.

Baines (2006) also identifies a key market trend, which applies across all food items. This is provenance, which involves associating the product with the origin, or source from which something comes, and the history of subsequent owners.
While this trend rooted in the food service sector it has rapidly moved across all areas of manufactured products. Customers link identifiable provenance with quality.
Micro trends also identified regarding flavour include

- Expanding Mediterranean,
- Light Asian, (mild aromatic Asian flavour)
- Floral Flavours

4.4.1 Functional foods

One macro trend evident is the increasing trend towards foods, which offer healthy attributes. These foods are termed functional foods (Blades, 2000).
Functional foods were invented by the Japanese in the early 1980's in response to an aging population, high health care costs and an acknowledgment of the link between diet and health. The concept of foods for specified health use (FOSHU) was established by the Japanese in 1991. Foods identified as FOSHU are required to have scientific evidence to substantiate their claims (Roberfroid, 2000)
Changing customers lifestyles have a significant impact on demand for foods, which offer health benefits (Blades, 2001). Goldburg (1994) defines functional foods as "any food or food ingredient that has a positive impact on an individuals health, physical performance or state of mind, in addition to its nutritive value. EC Directive 89/398 provides for special labelling rules for foods for particular nutritional uses (Cockbill, 1994). One of the categories that fall within this description is food that are designed to meet the particular nutritional requirements of people in a special physiological condition, enabling them to gain special benefit from the controlled consumption of certain substances. (Cockbill, 1994)

The full market potential for functional foods can only be maximised with the development of market-oriented products that gain consumer acceptance (Bogue, 2000, Bogue and Sorenson, 2005, Gray *et al.*, 2003). However consumers are not prepared to compromise intrinsic product attributes such as aroma, appearance, flavour and texture for a perceived health benefit (Sloan, 2000, Hill *et al.*, 2002; Urala and Lahteenmaki, 2003). These macro and micro trends are an important element of any New Product Development and therefore should be considered as part of concept development for future fish roe products.

4.4.2 Ethical consumerism

Research has consistently revealed an increasing demand for "ethical" choices in the global marketplace (Shaw and Shiu, 2003). Research by Davies (1995) identifies organic food as not being intensively produced and natural Being an ethical consumer means buying products which were ethically produced and/or which are not harmful to the environment and society. This can be as simple as buying free-range eggs or as complex as boycotting goods produced by child labour. Products which fall into the

ethical category include organic produce, fair trade goods, energy-efficient light bulbs, electricity from renewable energy, recycled paper and wood products (Url, 8). Ethical consumption can be a powerful tool for change, with the recent success of the anti-GM lobby being an example. Carolyn Strong (1996) in her article "Features contributing to the growth of ethical consumerism- a preliminary investigation" describes an ethical consumer as:

1. One who avoids products that are likely to endanger the health of the consumer or others: cause significant damage to the environment during manufacture, use or disposal.
2. Consume a disproportionate amount of energy.
3. Cause unnecessary waste: use materials derived from threatened species or environments.
4. Involve unnecessary use or cruelty to animals.
5. Adversely affect other countries.

In 2002 the total value of ethical consumption in the UK was £19.9 billion (Clavin *et al.,* 2003). While this represented only 2 % of total market share, it indicated that consumers acting as innovators in getting new products to the market have a minor impact and to achieve mass market adoption government intervention is necessary. The report defines ethics "as personal consumption where a choice of product or service exists which supports a particular ethical issue, be it human rights, the environment or animal welfare". Some key product classifications were identified: showing free range eggs accounting for 40% of the market and organic foods increasing 13% in market share. Other key factors highlighted by the report were

- The value attached to consumers switching brands for ethical reasons was an estimated 2.6 billion sterling in 2002.
- 787 million sterling of grocery was switched between brands for ethical reasons.
- Energy efficient electrical appliances accounted for 41% of market share.
- The growth in market share from a base line of 100 in 1999, the index showed an increase of 30 points at 130 in 2002.
- Ethical consumerism is a serious concern in relation to caviar and caviar products. With media focus on depletion of natural stocks giving rise to ethical concerns and a

risk of lowering demand, many companies have re directed their market focus. Marketing strategies based on sustainability and ethics are becoming more abundant. Grankvist and Lekedal (2007) show a clear preference and greater perceived benefits of environmentally friendly produce.

There are many factors which affect the global caviar and roe industry and these driving forces include the following;

- Decline of sturgeon population
- The growth of the aquaculture sector
- Conservation and pollution.
- Fishing regulations and restrictions.

4.4.3 Decline of sturgeon population

Sturgeons are among the world's most valuable wildlife resources. Since 1998, international trade in all species of sturgeons has been regulated under CITES owing to concerns over the impact of unsustainable harvesting of and illegal trade in sturgeon populations in the wild. The situation in the Caspian Sea, where most of the world's caviar is produced, became particularly worrying after the break-up of the Union of Soviet Socialist Republics, which led to the virtual collapse of existing management and control systems (De Meulenaer and Raymakers, 1996). The resulting over-exploitation of sturgeon stocks gave rise to recognition of the urgency to prevent further depletion and to restore the species stocks. But if Inga Saffron's recent book, *Caviar: the Strange History and Uncertain Future of the World's Most Coveted Delicacy*, is correct, the problems of Russian over fishing, poaching, barely enforced quotas, loose quality control, and a deeply diminished supply of sturgeon may signal a day when the taste of wild caviar will be no more than a dim memory.
The once abundance of Beluga *Huso Huso* in the Caspian Sea is decreasing. Beluga *Huso Huso* is also on the decline in the Black Sea (Anon, 1998, De Meulenaer and Raymakers, 1996). In the Danube River, the last major spawning river for Beluga *Huso Huso* in this region, the species is considered vulnerable: Beluga *Huso Huso* is on the verge of extinction in the Sea of Azov (Chebanov and Savelyeva, 1999).

Beluga *Huso Huso* sturgeon has lost 90% of their Volga River spawning grounds. The number of Beluga *Huso Huso* sturgeon entering Russia's Volga River to spawn dropped from 26,000 annually in the period 1961-1966 to 7,000 in the 1991-1995 period. Research indicates that during 1998-2002, an average of only 2,800 individuals were observed. In Kazakhstan's Ural River, the number of Beluga *Huso Huso* sturgeon entering river system declined from 3,900 individuals in 1994 to 2,500 individuals in 2002. Illegal catch has been estimated at six to ten and eleven times greater than legal catch in the Caspian and Azov seas, respectively. Illegal fishing is one of the main factors causing the continued decline in Beluga *Huso Huso* (Chebanov and Savelyeva, 1999). Catch of Beluga *Huso Huso* once exceeded 14,000 tonne in the early 1900s: catch levels in 1970 were only 2,800 tonne while the 2003 catch quota amounted to only 155 tonne. Trawl surveys conducted in the Caspian in 2001, found sixty-four Beluga *Huso Huso* sturgeon in the three hundred and fifty five trawl catches conducted, for a ratio of 0.18 Beluga *Huso Huso* per trawl tow. In 2002, a total of thirty-eight Beluga *Huso Huso* were caught in three hundred and thirty three trawl tows, for a ratio of 0.11 Beluga *Huso Huso* sturgeon per trawl tow. Based upon these sources, this indicates a 39% decline in Beluga *Huso Huso* sturgeon abundance between 2001 and 2002.
Improved domestic and international fisheries management and attention to habitat and species restoration are now needed. Although captive rearing offers promise for caviar alternatives and endangered species restoration, it must advance cautiously to avoid environmental harm (Pikitch *et al.*, 2005).

The Secretariat of CITES (January 2005) refused to publish 2006 export quotas for caviar until exporting countries provided more information about the sustainability of their sturgeon catch. "Countries wishing to export *sturgeon products from shared stocks must demonstrate that their proposed catch and export quotas reflect current population trends and are sustainable"* Willem Wijnstekers (CITES secretary-general).

Russian authorities believe that for every registered 1,000 tonnes of caviar, there is 12-14,000 tonnes placed on the black market (Fletcher, 2006). The 169 member countries of CITES have set strict conditions for permitting caviar exports. Countries sharing sturgeon stocks must agree amongst themselves on catch and export quotas based on

scientific surveys of the stocks. They must also adopt a regional conservation strategy. Importers such as the European Union also have important obligations. They must ensure that all imports are from legal sources, and they must establish registration systems for their domestic processing and repackaging plants and rules for the labelling of repackaged caviar.

In September 2005, The United States banned Beluga *Huso Huso* caviar imports from Caspian Sea nations after they failed to provide evidence of improved conservation plans for Beluga *Huso Huso* sturgeon, which the U.S. Fish and Wildlife Service declared a threatened species (Url, 5).

The United States had been the largest importer of Beluga *Huso Huso* caviar (60%) for the several years previous. "*Because a small amount of Beluga caviar may remain on the market, we continue to urge consumers to instead choose exquisite farmed American caviars, which are a better choice for the environment*" was the recommendation from Caviar Emptor – a coalition of SeaWeb (a communications-based non-profit organisation that uses social marketing techniques to advance ocean conservation), Natural Resources Defense Council and the University of Miami's Pew Institute for Ocean Science.

Cardinal *et al.,* (2002) evaluate and compare the sensory properties of caviar both from farmed and wild sturgeon. One of the key findings was the sensory properties of caviar was more determined by the species rather than the rearing method.

4.4.3.1 Global aquaculture of sturgeon

The United States (US) once produced about 90% of the world's caviar. As supply dwindled, however, so did production. The U.S. and more than a dozen other countries in similar circumstances have begun sturgeon-farming operations to preserve both the species and the industry (Williot *et al*., 2001). Commonly farmed varieties are *Osetra Acipenser sturio* Baerii, and White Sturgeon. Their roe is harvested at the ideal time for premium quality caviar. For consumers it means consistently high quality, lower-priced caviar, not from endangered stock.

Caviar of farm-raised Baerii produced in the Aquitaine region of the South-West of France is noted for its gastronomic excellence, equal to Beluga *Huso Huso* caviar from

the Caspian Sea. This fresh product comes from Siberian sturgeon raised on French aqua farms. It is characterised by large grains ranging in colour from grey to golden brown. Many other Caspian Sea bordering countries who are traditional producers have turned more to aquaculture to fill market voids (Chebanov and Savelyeva, 1999) For many, the concern regarding depletion of natural stock has given rise to strategic marketing of farmed products. These are been marketed as sustainable and ethically produced and harvested roe, which do not have a negative effect on natural habitats. Caprino *et al.,* (2008) highlights that farmed caviar is able to maintain good eating qualities, while representing an environmentally friendly and cost effective alternatives to wild products. Care and strict regulations must ensure quality management of these resources.

4.4.4 Conservation of natural resources

Conservation is defined as "management of the human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations. It includes the preservation, maintenance, sustainable utilisation, restoration and enhancement of the environment" (Url, 3). Management of natural resources is essential for the sustainability of the global seafood industry. Thousands of species around the world are endangered or at risk as a result of human activities such as habitat destruction, over-harvesting and pollution (Anon, 2003, Boelens, 2003). CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) was adopted in 1973 to address the threat posed by just one of these activities: unsustainable international trade. CITES is one of the world's most important agreements on species conservation and the non-detrimental use of wildlife. CITES is an international agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. Since April 1998 the international trade of 25 species of sturgeon and 2 paddlefish *Polyodon spathula* have been monitored and controlled (Williot *et al.,* 2002). CITES works by subjecting international trade in specimens of selected species to certain controls. All import, export, re-export and introduction from the sea of species covered by the Convention have to be authorized through a licensing system.

Research is ongoing into a molecular method for species identification of sturgeon products, with particular emphasis on black caviar (Ludwig *et al.*, 2002). Aranishi *et al.*, (2005) offers a solution for identification of the illegal substitution of ingredient roe of related fishes e.g. cod *Gadus morhua* and Pollock *Theragra chalcogramma*. In Ireland, management, scientific and enforcement duties are the responsibility of National Parks and Wildlife Service. Management of natural resources is essential for the sustainability of the global seafood industry.

A study was conducted into ecological balance and the current decline of oceanic zooplankton, microscopic organisms that float freely with oceanic currents and in other bodies of water (MacKenzie, 2002). Pelagic spawn released by marine fish and invertebrates is accessible food to this carnivorous zooplankton. The massive reduction in spawning stocks of many marine species has been induced by over fishing (MacKenzie, 2002). Protection and maintenance of natural habitats is vital. (Irvine, 1987), a is the realisation that maximising the production of 'all spawn' in the sea needs to become a management priority (MacKenzie, 2002).

4.4.5 Pollution

Pollution is the release of harmful environmental contaminants, or the substances so released, or an alteration in the character or quality of the environment (Saffron, 2002), or any of its components, that renders it less suited for certain uses; The alteration of the physical, chemical or biological properties of water by the introduction of any substance that renders the water harmful to use (Url, 4).

The presence of pollution is partially to blame for the decline of sturgeon in once abundant regions (Saffron, 2002, Anon, 2003). Due to a lack of food and pollution, only 4% of the Beluga *Huso Huso* caught in the 2002 trawl surveys of Northern Caspian feeding grounds had full stomachs: in general, stomach contents consisted of algae paper and cellophane packages (Url, 5).

Another form of pollution responsible for the decline in numbers of wild sturgeon which is equally as damaging as over fishing is the construction of dams on natural waterways restricting animals from returning to spawn (Saffron, 2002). Due to dam construction, Beluga *Huso Huso* has lost almost all its natural spawning sites. During the last few years Beluga *Huso Huso* has not been restocked artificially in Russia due to a lack of wild breeders. The erection of dams on waterways also affect other fish

that swim upstream to spawn. These include salmon *Salmo salar/ Oncorhynchus nerka* and paddlefish *Polyodon spathula*. Both shrimp and salmon farms use pesticides and antibiotics, and their waste pollutes surrounding areas. Habitats are slowing changing and little is known of the true future risk to ocean life.

4.4.5.1 Aquaculture related pollution

Aquaculture has a number of economic and other benefits. But if there are not adequate environmental safeguards it can cause environmental degradation (Al-Holy *et al.*, 2004). The main environmental effects of marine aquaculture can be divided into the following five categories:

1. Biological Pollution: Fish that escape from aquaculture facilities may harm wild fish populations through competition and interbreeding, or by spreading diseases and parasites. Escaped farmed Atlantic salmon *Salmo salar/ Oncorhynchus nerka* are a particular problem, and may threaten endangered wild Atlantic salmon *Salmo salar* (Eng *et al.*, 1989).
2. Fish for Fish Feeds: Some types of aquaculture use large quantities of wild-caught fish as feed ingredients, and thus indirectly affect marine ecosystems thousands of miles from fish farms
3. Organic Pollution and Eutrophication (The process by which a body of water becomes rich in dissolved nutrients, thereby encouraging the growth and decomposition of oxygen-depleting plant life and resulting in harm to other organisms): Some aquaculture systems contribute to nutrient loading through discharges of fish wastes and uneaten feed.
4. Chemical Pollution: A variety of approved chemicals are used in aquaculture, including antibiotics and pesticides.
5. Habitat Modification: Marine aquaculture is based in natural habitats, which will be destroyed by the existence of the farm (Goldburg, 2001). Some facilities attract marine predators, and can harm them through accidental entanglement or intentional trapping.

There is also concern in the increasing deterioration of coastal water quality resulting from the discharge of domestic, agricultural and industrial wastes into coastal waters have affected aquaculture production and profitability (Eng *et al.*, 1989).
Sustainability is becoming the key to preservation and is currently under media focus

4.4.6 Fishing regulations

Fishing regulations are necessary to protect fish stocks and to ensure the future of the fishing industry (McDermott, 1996). Disregarding regulatory measures would result in over fishing, damage to commercial stocks and, ultimately, ruin for the whole industry. The European Union implemented a Common Fisheries Policy (CFP), applicable to each of its Member States, in 1983. This policy is implemented primarily through the tabulation and enforcement of fish quotas in the form of Total Allowable Catches (TACs), and attempts to regulate the size of Member States' fishing fleets (Morin, 2002). These TACs are re formatted each year and special consideration is given to the requirements of each of the member states and the protection of the natural marine stock. The Commission is also involved in a number of other fishing related decisions; for example, it decides permissible net sizes, and therefore the potential for undersize fish to escape and the horsepower of fishing boats and other technical measures.

A report on Common Fisheries Policy highlights the following faults to its implementation: fishermen use to get around TACs by throwing fish they deem to be too small back into the sea, where they are left to die. This is known as "by-catch"(Anderson, 2006). In doing this, fishermen are further depleting future fish stocks. British and Dutch scientists have estimated that for every pound of sole dragged off the sea-bottom, some North Sea beam trawlers discard 10 pounds of by-catch (Greenstreeta *et al.*, 2006). Global by-catch is estimated at about a third of all fish caught (Alverson, 1993). The gap between actual and recorded catches is widening, as fishermen complain that quotas are set too low, and as more cautious TACs lend to greater discarding and more "black" trading, a term used to describe fishermen failing to record their entire catch and selling the surplus on the black market. This has the effect of distorting market price and also makes implementation of a common fisheries policy more strenuous. Black trading is taken into consideration when quotas are been set (McDermott, 1996)

5 Irish Market Analysis (Micro).

The Irish seafood industry is a vital contributor to the Irish economy. Total Irish sales in seafood in 2006 amounted to €724.6 million (Anon, 2006a). This showed a 9% increase on the previous year, mainly due to growth in the domestic market. The revenue breakdown for 2006 is as follows:

Retail market: €157.7 million

Food service sector: €204.7 million

Exports: € 362.2 million

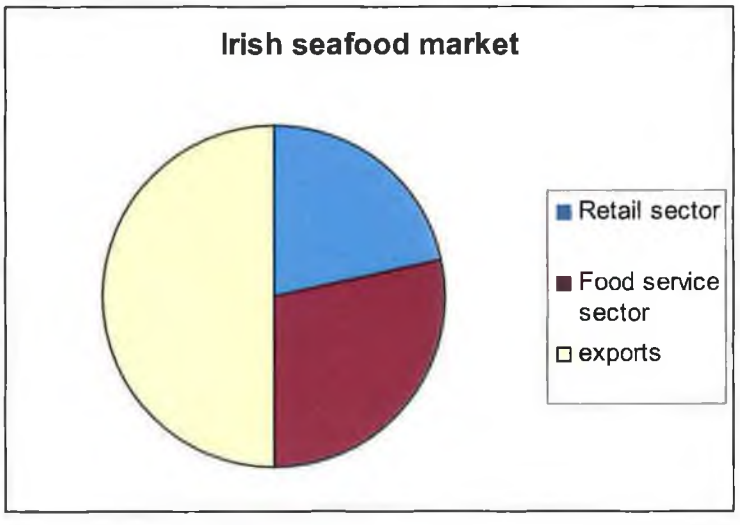


Fig. 3 Irish seafood market revenue breakdown by sector (Anon 2006a)

There was a market increase on all areas from 2005 with an increase of 15% in the retail sector, 18% in the food service sector and 2% increase in exports. The BIM annual review 2006 identified the main reason for growth as being the increased awareness of health and nutritional benefits associated with seafood. Total BIM and EU grants for 2006 amounted to €27.6 million of grant aided investment with associated BIM/EU grants payments of €12.5 million. Aquaculture accounted for 48% if this investment with processing and marketing achieving 24% of grant aided investment.

The increased demand for domestic consumption was satisfied by an increase of 16% in imports to a value of €144 million. The most notable trend in exports was a decline

in pelagic exports of €78.8 million (27%) and an increase in shellfish exports to €147 million (16%).

The BIM annual review for 2006 (Anon 2006a) outlined the value of the Irish seafood industry to the country's economy. Key trends in the sector were identified as

- Relative buoyant markets
- Tight quota restrictions
- Reduced raw material supplies
- Higher operating costs, with processing and labour becoming less competitive relative to global markets.

Quotas for 2007 showed some significant changes (Url, 9). The following is a synopsis of these modifications. Quotas were increased for mackerel *Scomber scombrus*, plaice *Pleuronectes platessa*, prawns, and haddock *Melanogrammus aeglefinus*. Quotas for whiting *Merlangius merlangus*, herring *Clupea harengus*, saithe and cod *Gadus morhua* were reduced.

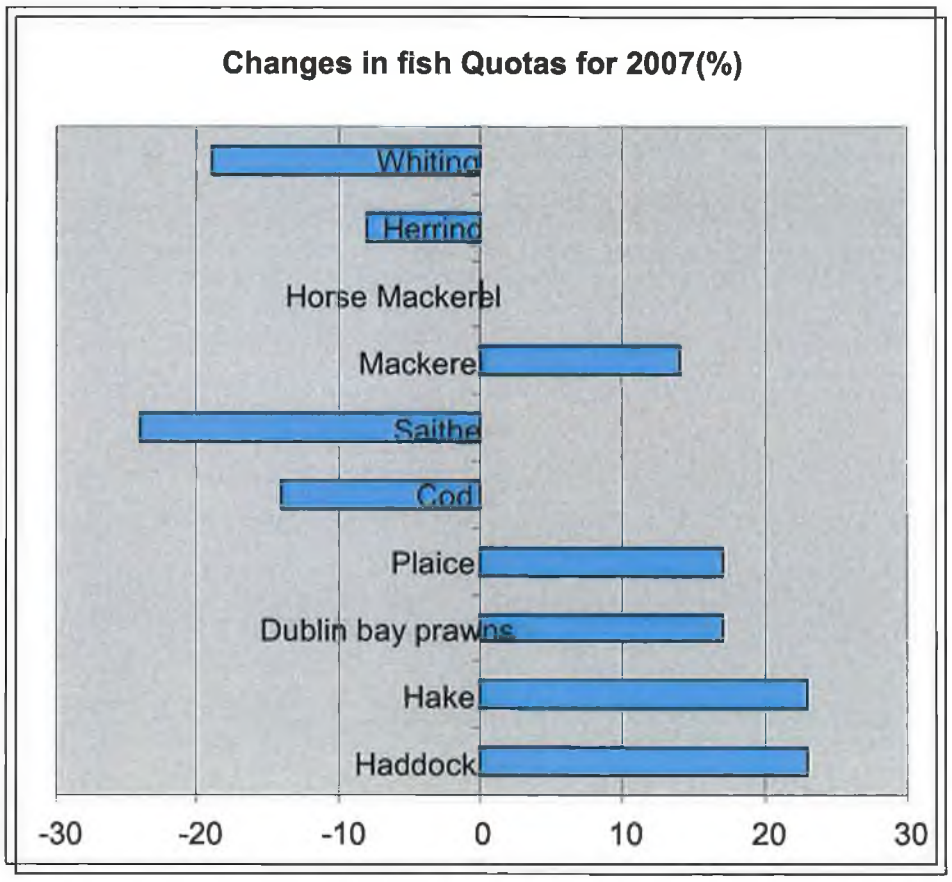


Fig. 4 Change in fish quotas for Ireland for 2007, (Url,, 9)

5.1 The Seafood Sector Development Strategy

The Seafood Sector Development Strategy 2007 –2013 (Anon, 2006b) is a strategy developed to secure a sustainable and profitable Irish seafood sector. The aim of this strategy is to develop a comprehensive integrated market led vision for the future of the Irish seafood sector, based on a strategy centred on innovation, product development and value maximisation for coastal communities, which reflects the need for sustainable management of marine resources and ecosystems in the waters around Ireland (Anon, 2006b). The strategy hopes to

- "address the potential for development in sea fisheries (both inshore and offshore), aquaculture, seafood processing and marketing.
- concentrate on improving the management, competitiveness, structures and profitability across all sectors of the industry including sea fishing, aquaculture, processing, marketing and support industries.
- examine the potential for innovation, product development and value enhancement of primary aquaculture production and shellfish, whitefish and pelagic fish landed into Ireland, Examine impacts of shortages of crew and associated training issues.
- prioritise the delivery of an environmentally sustainable aquaculture and sea fisheries sector that maximises employment and economic activity in Irish communities dependent on fishing and aquaculture.
- achieve an urgent adjustment of fishing effort and fleet capacity to achieve a balance with available fishing opportunities so as to contribute to the long-term sustainability of those fishery resources on which the sector critically depends.
- achieve structural adjustment in the processing sector to enhance coordination nationally of processing and marketing of uniformly high quality products with strong competitive impact on markets.
- take a holistic view of all fleets operating proximate to Ireland and seek in the context of increasing energy costs to maximize the growing opportunities to benefit Irish land based industries and coastal communities from these fishing activities.

- promote the growth of a competitive, consume orientated, market-led, added value seafood sector: Maximises the possibilities for synergies with other sectors of the Irish food industry in the areas of food research, innovation, product development and integrated marketing. (Anon, 2007)

The development of the strategy is to proceed within the framework of the Common Fisheries Policy and National Fisheries Law and is intended, as one of the outputs, to feed in to the National Strategic Plan, which is required under the European Fisheries Fund 2007 to 2013(Anon, 2007).
The areas of greatest importance in light of this project are the emphasis on value added products, and maximising output from current stocks a method of growing the industry.

5.2 Irish Aquaculture

Irish aquaculture has become an important part of the national economy, with a steady out put of over 120 million in 2006. This included a 5% increase in farmed salmon (Anon, 2006d). Production last year reached 42,371 tonnes of shellfish and 16,040 tonnes of finfish, including salmon, trout *Oncorhynchus mykiss* and arctic char. Production value had grown from €37.2 million (26,573 tonnes) in 1990 to a peak in 2002 of €125 million (60,984 tonnes). Since then, the industry experienced significant production and marketing challenges and in 2006 production was valued at €120.214 million (58,411 tonnes)(Anon 2006d). Nevertheless, aquaculture represents some 30% of the total value of Irish seafood produce with a further €13.352 million invested in the industry in 2006 (Anon 2006d).

5.2.1 Driving forces

The Irish Aquaculture industry is showing great resilience in light of driving forces. Growth of the industry may be affected by difficulties in procuring licences, poor commercial perception and lack of investor confidence in the market. The driving forces in the aquaculture sector have been identified by BIM (Anon 2006a) as;

- Low-cost selling by salmon producers in Chile and Norway i.e. fish dumping.
- Reported difficulties with disease

- Development of new species
- Ethical consumerism and concerns regarding sustainability.
- The disposal of waste material from the fish processing industry (Pfeiffer, 2003)

5.2.1.1 Fish dumping

Norwegian companies have sold farmed salmon on the European community (EC) market at illegal dumped prices, putting the viability of Irish aquaculture in jeopardy (Anon 2006a). The European Council, with broad support from the Member States, on 17 January 2006 acknowledged the necessity to adopt anti-dumping measures in accordance with WTO (World Trade Organisation) rules. The minimum price has been set at €2.80 per kilo of fresh salmon to reflect market production costs in Norway. Unlike the imposition of a tariff, the setting of a minimum import price does not add additional costs for Norwegian exporters if they respect this price. It ensures in a simple and transparent manner that Norwegian producers do not sell products in the EU below the cost of production in Norway. The use of a minimum price also guarantees the European processing industry and consumers a stable and secure supply of fresh salmon at a fair price. This re-creates confidence in the home market and the potential for further investment (Anon 2006b).

5.2.1.2 Disease

The industry faces many difficulties with disease primarily Pancrease Disease (PD) and Infectious Pancreatic Necrosis (IPN) and the destruction of stock by sea lice. Sea lice are regarded as having the most commercially damaging effect on cultured salmon in the world with major economic losses to the fish farming community resulting each year (Anon, 2006d). They inflict damage to their hosts through their feeding activity on the host's body. Sea lice affect salmon in a variety of ways: mainly by reducing fish growth, loss of scales which leaves the fish open to secondary infections and damaging of fish which reduces marketability (Anon, 2006d).

5.2.1.3 Development of new species

The Status of Aquaculture Report (Anon 2005b) highlights the development of new species, the first trial of marine fish farming for a species other than salmon and trout *Oncorhynchus mykiss* took place in 2005 in Galway, when juvenile cod *Gadus morhua*

were cultured . Cod *Gadus morhua* is identified as an ideal investment as there is a developing knowledge base concerning it's cultivation, both from eggs using captive brood stock and as an on-grown product based on wild captured juveniles (Anon 2005b). Cod is suitable for cultivation in Irish waters and Ireland holds several distinct races of cod, all of which are under severe exploitation and stock pressure. Technology developed for cod is likely to be readily transferable to other white fish species, especially gadoids such as haddock *Melanogrammus aeglefinus.* Certain technical methods could also be used to farm species such as hake *Merluccius merluccius* (Anon, 2006a).

Arctic char is also farmed in Ireland. This process is in its infancy relative to its close relatives, salmon and trout *Oncorhynchus mykiss*. This is deemed to be an ideal fish for farming in Ireland as it is native to Ireland and has existed since the ice age. Arctic char favour cold water and is both a freshwater and saltwater fish. Arctic Char at was less successful at sea as juveniles once released failed to survive the autumn (Gjedrem, 1975, Gjedrem and Gunnes, 1978). Cloonacool in County Sligo is home to one of Irelands Arctic Char farms and have successfully reared the fish to harvest. Arctic Char produce roe similar to that of Salmon *Salmo salar/ Oncorhynchus nerka* and trout with a slightly darker pleasant colour. Roe is produced at an early stage and there remains a good balance between flesh quality and roe content.

The potential of the native Irish species of sea urchin namely, *Paracentrotus lividus* (the purple urchin) and *Psammechinus miliaris (the green sea urchin)*, as a candidate for aquaculture in Ireland has been the subject of research and investigation in Ireland for many years (Moylan, 1993). Brood stock conditioning, hatchery and early nursery on growing requirements of the purple urchin were assessed at the Shellfish Research Laboratory, UCG, Carna, Co. Galway during the 1980 and 1990's. As a direct result, the first commercial hatchery in the country was established in Dunmanus Co. Cork during the early 1990's. The hatchery has expanded rapidly with its main focus being on the production of juveniles and its current production capacity is nearing 1 million, 10-20mm juveniles per year (Anon, 2005b). In line with the development of hatcheries, aquaculture licenses were acquired by private companies for the purpose of growing these juveniles to

mature specimen (Url, 10). Sea Urchin roe is in strong demand on global markets, but Irish market has declined since the 1960s due to over fishing (Moylan,1994)

5.2.1.4 Disposal of waste material from the fish processing industry.

A report commissioned by the Marine Institute and conducted by Pfeiffer (2003) deals specifically with the problems associated with disposal of fish waste generated by the fish processing and aquaculture sectors. While this report does not deal with fish roe specifically or the actual cost to the industry of waste disposal, it highlights the difficulties facing the industry with regard to waste management of which roe is an ingredient. For some species, new product development may provide opportunities to utilise more edible parts of the fish within finished products, adding value and therefore increasing profit. The report recognises that while Irish seafood consumers are relatively conservative, there is potential to develop novel products for the home market but more so for the more adventurous export markets (Pfeiffer (2003). One of the key recommendations of the report is the consideration of product development to incorporate more edible parts of the raw material and production changes to increase product yield, which will minimise solid waste. Also highlighted in this report is the necessity for a waste audit to be conducted and the commitment required by BIM and Environmental Protection Agency (EPA). This proposed audit could be of vital importance in the allocation of funds to develop particular differentiated products for various sectors within the roe market.

6 Research Findings

6.1 Industry survey

6.1.1 Introduction

An electronic questionnaire was developed and circulated to Irish based seafood producers to enable the researcher to identify the activity in the areas of new product development, to assess current production methods utilised, to determine past and current production of roe products, and to determine interest in future product development.

This is deemed to be vital as it is important to quantify levels of interest, to identify intellectual capital existing in the industry, and to determine if there is an interest in future product development. Established strategic alliances with identified markets will inevitably give strong advantage to competitors intending to diversify.

6.1.2 Results of questionnaire

The questionnaire was drafted and tested on five individuals to identify questions that may cause confusion and vagueness and to asses if the format was easily filled electronically (Appendix 1).

The target sample selected consisted of the entire list of seafood product suppliers from the BIM database. This consisted of 219 contacts with varying seafood product categories. This proved an easy sample to target by electronic mail as the E-mail addresses of these companies are listed on the BIM web site. From the 219 sample, 21 e-mails were not deliverable as the information on the database was inaccurate. Notification of this was communicated to BIM and the web details have since been updated. From the remaining 198 sampling units, after the initial communication and a further reminder 43 surveys were returned. One of these proved to be spoiled, as it was incomplete, resulting in a 21% return rate.

The following is a synopsis of the results. For confidentiality reasons company names are not identified.

The initial two questions were

Question 1: How many employees in your company?

Question 2: Is your company actively involved in research development?

The majority of companies are relatively small with less than 20 employees. 71.4% of respondents claim to be actively involved in research and development. Regardless of the scale of research and development, this shows an interest in future product development. There was no clear distinction between the smaller and larger companies who were involved in research and development.

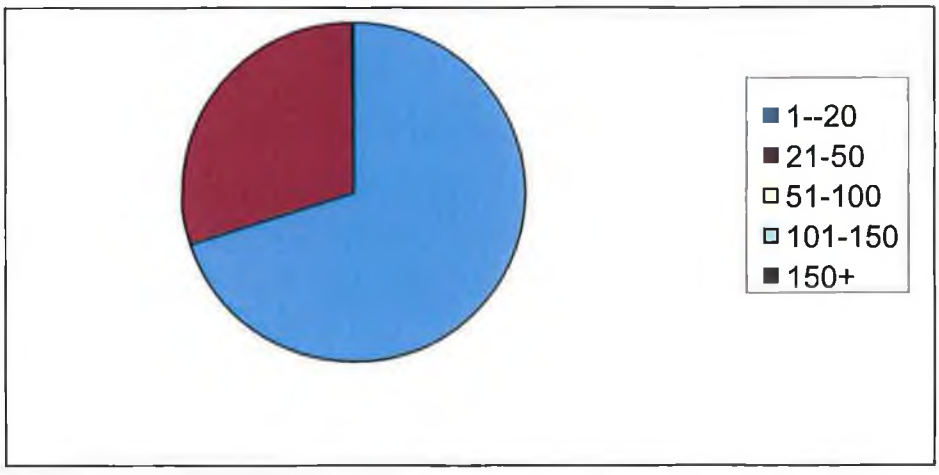


Fig. 5 Number of employees per company surveyed in the Irish seafood sector 2006

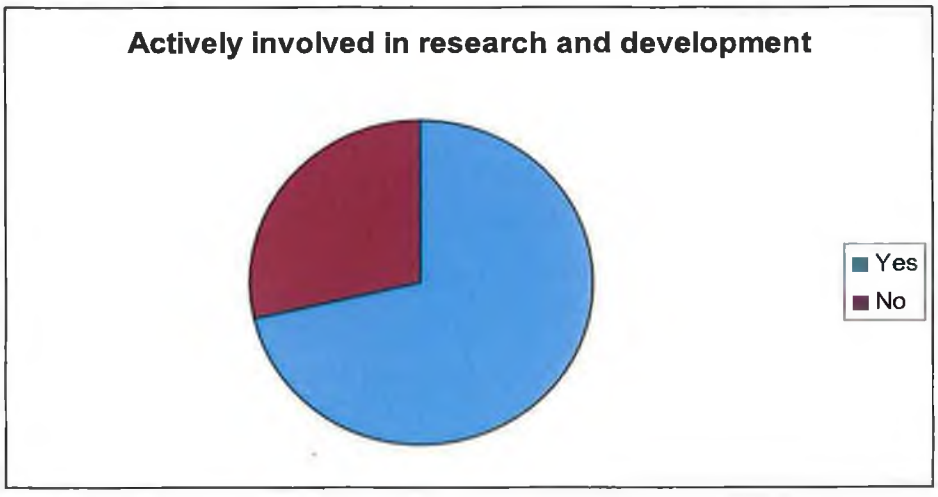


Fig. 6 Surveyed companies actively involved in research and development in Ireland 2006.

Question 3: What methods of production are you currently utilising?

The methods of production currently being used in the industry by the majority of respondents are chilling, freezing, brining and smoking.

Table 11 Processing methods employed by surveyed companies in Ireland 2006

Canning/bottling 4.7%
Brining 33%
Chilling 57%
Freezing 28.5%
High-pressure processing 2.3%
Smoking 28.5%
Cook freeze 4.76%

This highlights the areas of expertise in the seafood industry. Any new product development will achieve greater benefits and economies of scale if aligned with current expertise. The larger companies were involved in the more advanced processing methods, while the smaller companies were mostly involved in chilling and freezing.

Question 4 and 5: Is your company currently exporting?

To what countries are you currently exporting?

All respondents are currently exporting and the following is breakdown of export activity. Of the surveyed population, 85.7% already export produce to Europe, 38.1% have exports to Japan and 9% have expertise exporting to the US. This expertise and strategic alliances which may have been developed can be invaluable if developing new products for existing markets.

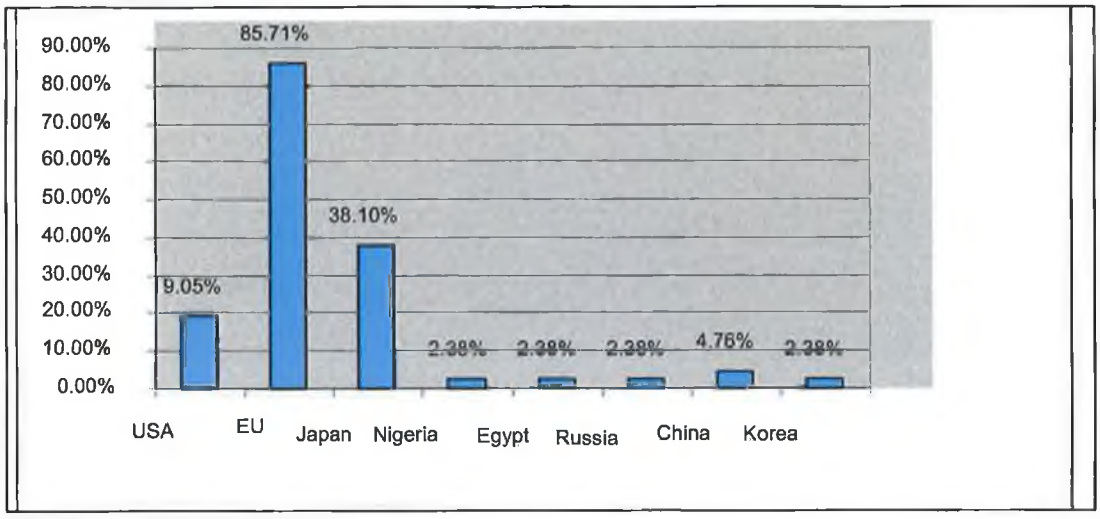


Fig. 7 Export destinations of marine produce of survey participants in Ireland 2006.

Question 6 and 7: Have you produced roe products in the past?
Are you currently involved in fish roe production?

Of the completed sample there were three companies identified which were involved in roe production and these were herring products. A further four companies had a historical record of production of cod roe products.

Question 8 and 9: Are you interested in future production of fish roe products?
Are you interested in viewing the findings of this report?

Sixteen of the returned sample (40%) expressed an interest in future roe production while twenty-four expressed an interest in the findings of the report.

To identify more closely with the companies interested in production of roe products, a further breakdown of the particular sample was conducted. The results showed that 40% claim to be interested in roe production in the future. The methods of production currently being utilised by the interested companies are as follows, chilling, brining, freezing, smoking and high pressure processing. When developing new products it is more cost effective to utilise current expertise within the company and also using current export destinations can be beneficial.

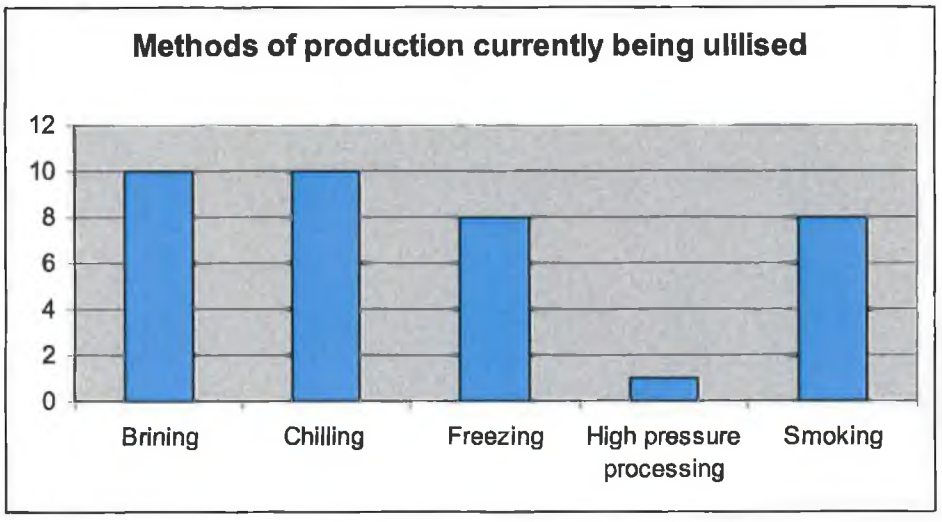


Fig. 8 Methods of production currently utilised by companies interested in future production

The current destinations for exports by participants interested (40% of surveyed population) in the development of roe products are

- United States -25%
- EU-88%
- Japan-50%
- Nigeria-13%
- Korea-13%
- Russia-13%
- China-13%

Market knowledge and access to identified markets are vital for the introduction of new products.

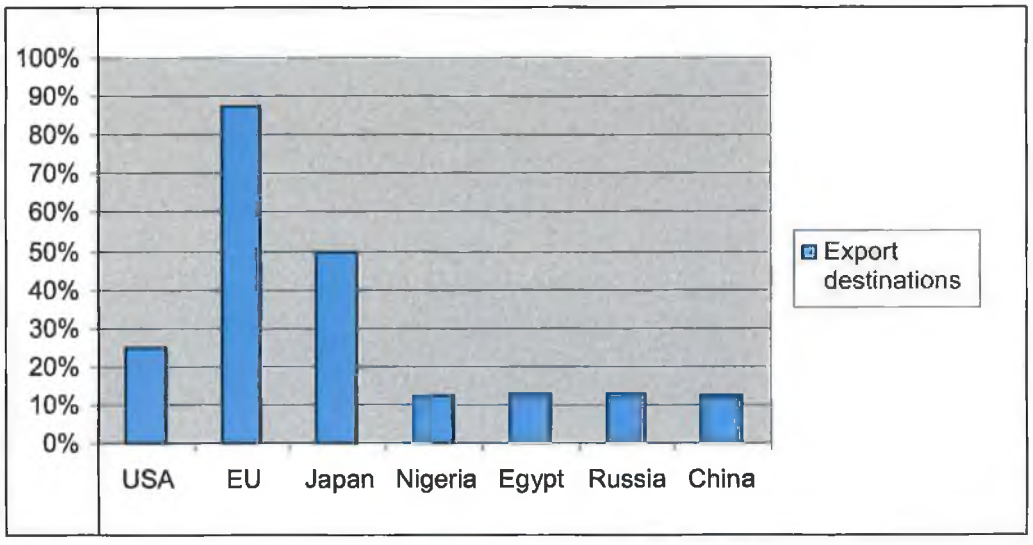


Fig. 9 Export destinations of interested companies exports

6.1.3 Conclusion of industry survey

The industry is very diverse and fragmented. A wide range of markets are being target by Irish seafood industries. There is little historical or current activity in roe production. Historical activity was based on cod *Gadus morhua* roe, while current activity identified is based on herring *Clupea harengus* roe. 40% of respondents indicated an interest in future involvement in the roe industry. Areas of expertise of these respondents include Brining, freezing, smoking and chilling. Potential market destinations for future roe products are highlighted. There is market knowledge and activity in many export destinations, the greatest of these being Europe, United States and Germany.

There is a potential for these companies to diversify their product range by utilising strategic alliances, current production methods for current export destinations.

6.2 Participant observation

To develop a better understanding of major roe markets identified, the following participant observation was conducted:

- An observation of markets in Tokyo with particular emphasis on Tsukiji fish market 2005.
- A visit to The Boston seafood show 2005, 2006,the largest seafood show in United States,
- An observation of products and trends at the European Seafood Exposition 2007
- An observation of products and trends at the Mediterranean Seafood Exposition (MSE) 2007,

6.2.1 Tsukiji Fish Market

The Tsukiji fish market in Tokyo handles more than 400 different types of seafood from tiny sardines to 300kg tuna *Thunnus*, from cheap seaweed to the most expensive caviar. Tsukiji handles over 2000 metric tons of seafood per day. The number of registered employees varies from 60,000 to 65,000, including wholesalers, accountants, auctioneers, company officials, and distributors. There are two other smaller markets within Tokyo, but Tsukiji boasts 87% of the total market. The market is conducted with great precision. At 5:00pm the market begins to receive goods. Fresh foods and others pour in from various parts of the world by truck, plane and ship. Then at 3:00 a.m. before daybreak, wholesalers lay out the goods in preparation for the start of the auction. It is important that the goods received on the day sell out within the day to ensure freshness. At 8:00 a.m. retailers load the goods which they have bought at the market into their trucks. The majority of seafood consumed in Tokyo originated in Tsukiji and therefore a very important market to penetrate.

On a visit to Tsukiji, it was evident that quality was a prerequisite to supplying the market. Roe products available on the market were salmon *Salmo salar/ Oncorhynchus* nerka, trout *Oncorhynchus mykiss*, cod *Gadus morhua*, herring *Clupea*

harengus, sea urchin (uni) and hake *Merluccius merluccius* roe. Through discussion with market personnel it was identified that

- Quality of roe presented to the market was essential.
- The preferred products for Japanese import were prime unprocessed product as Japan operates high standards in processing.
- The most common methods of receiving roe products to the market were frozen, chilled or floated in brine. Floating in light concentration of brine prevents any pressure damage to the product and also stops deterioration of products in transportation.
- Some dried salted herring roe was also present, which had been packaged to high specification for the Christmas and New Year market.
- Developing a strong strategic alliance within the Japanese fish market is a key success factor for exporters to Japan. Such alliance may take years to build, as within Japanese culture, building relationships is vital for business. There is little focus on short-term profits with greater emphasis on establishing long-term foundations (O Leary, 2006).
- Fast reliable freight access routes are essential.
- Large volumes of roe pass through the Tsukiji market each year, including Pollock, *Salmon*, trout, herring, sea urchin, sole, mullet, hake and whiting roe.

The following are samples of product available on the market at Tsukiji

Salmon roe – chilled. Almost all roe were in perfect condition with the outer protective film intact.

Fig. 10 Salmon roe on sale at Tsukiji Market, Tokyo.

Hake roe - chilled

Fig. 11 Hake roe on display at Tsukiji Market, Tokyo.

Presentation boxes of Salted Herring *Clupea harengus* roe

Fig. 12 Salted herring roe on display at Tsukiji Market, Tokyo.

Herring *Clupea harengus* roe floated in brine for transportation

Fig. 13 Herring roe floated in brine displayed at Tsukiji Market, Tokyo.

6.2.2 The Boston seafood Show

The Boston seafood Show offers a showcase held annually, for seafood producers. This is the single largest event of its kind in America and a great show case for what America has to offer (Anderson, 2006). Trends in the roe sector of the market tend to focus on highly differentiated value added products. The product offering included

- Various flavoured and coloured roe products designed to simulate caviar.
- Cream cheese flavoured and coloured with caviar substitute, presented in a piping bag, convenient for quick presentation of canapés and buffet work.
- American brined caviar in Jars.
- Fresh salmon roe.
- Brined salmon roe in Jars.

- Fresh and preserved trout roe.

Many companies with roe on their product list did not display products and emphasised the strong demand, far exceeding supply. An in-depth interview with one supplier (Stoller Fisheries) relayed that his product goes out to tender to Scandinavian ocean liners six months prior to harvest, and the product goes to the highest bidder. Stoller fisheries based in Iowa harvest roe from Lake white fish (*Coregonus clupeaformis*) and Carp *Cyprinus carpio*. The white fish roe is generally sold on processed, as white fish caviar while the carp *Cyprinus carpio* roe is pressed and salted. As the fishing method involves drilling through ice, global warming already is showing a negative impact on the length of the fishing season thus reducing the output of these products.

Anderson (2006) identifies trends for the future. These include

- A continued growth but most of it fuelled by aquaculture imports. Per capita seafood consumption will see increases but will be concentrated on fewer species produced primarily in aquaculture facilities.
- The Diversity is in the "sauce". Growth in aquaculture parallels a shift in the market towards value-added products that enhance consumer convenience.
- Technological innovations, better nutrition and disease management will continue to reduce costs in aquaculture production.
- Potential constraints for aquaculture development (e.g.,"fishmeal trap") will be circumvented by new technology and substitution.

6.2.3 European Seafood Exposition

Trends at the exhibition 2007 (personal observation) highlighted sustainability and ethics as being key strategies for many companies. Value added products showed great variety and diversity. These products involved fresh caviar from natural sources and farmed caviar (mainly American) and also products involving the processing of

1. Salmon roe, in colours varying from bright orange to dark red. Both wild and farmed with farmed products being marketed as sustainable.
2. Trout roe, both wild and farmed, natural colour.
3. Lumpfish roe, in a variety of vibrant colours and various flavours.
4. Flying fish roe. With wasabi and tobikko and a variety of colours.

5. Mullet *Mugil cephalus* roe, smoked, dyed (with a natural dye) black and sold as mullet caviar.
6. Herring *Clupea harengus* roe, smoked, then dyed black and red which is suitable for both cooking and presentation (Spanish product).
7. Farmed caviars boasting core values of environmental conservation and sustainable development
8. Whitefish roe, in its natural golden colour and also dyed black and red.
9. Imitation caviar from a seaweed base. This product boasts as its unique selling point (USP), a lower level of salt than real caviar and a firmer bite, is 100% vegetarian, is 100% cholesterol-free, does not affect endangered fish species, has a 24 month shelf life in normal room temperature when unopened and does not go rancid after the jar is opened, therefore waste is limited.

At this years event Greenpeace activists challenged the exhibitors and attendees at the European Seafood Exposition 2007 about the sustainability of the seafood being bought and sold at the event (Url,11) The argument delivered by the activists was as follows: According to UN Food and Agriculture Organization data, over three quarters of all commercially valuable fish stocks are already fully exploited, overexploited or depleted. Worldwide, up to 90% of stocks of large predatory fish like cod *Gadus morhua*, tuna *Thunnus* and swordfish *Xiphias gladius* have already been fished out. According to Greenpeace all these and hundreds of other destructively fished seafood species are being marketed at the European Seafood Exposition 2007, the world's largest seafood event. This further highlights the growth in ethical consumerism and a need for a sustainable market focus.

6.2.4 The Mediterranean Seafood Exposition (MSE)

The main focus of the Mediterranean Seafood Exposition (personal observation) was on unprocessed fish and shellfish. There were little value added products on display and a complete absence of caviar and roe products.

6.3 Industry and competitive analysis

6.3.1 Introduction

An industry and competitive analysis identifies economic traits and competitive conditions and how they are expected to change, thus determining the profit and success prospects. Porter (cited by Thomson and Strickland, 2003) identifies seven key questions which determine the attractiveness of the industry. The industry analysis conducted is based on the world roe industry, as it is a global marketplace.
These questions uncover industry and competitive analysis. The seven questions outlined are:

1. *What are the industry's dominant economic features*
2. *What is competition like and how strong are each of the competitive forces.*
3. *What is causing the industry's competitive structure and business environment to change*
4. *Which companies are in the strongest/weakest positions?*
5. *What strategic moves are rivals likely to make next*
6. *What are the key factors for competitive success*
7. *Is the industry attractive and what is the prospect for above average profitability:*

(Thomson and Strickland, 2003)

6.3.2 What are the industry's dominant economic features (1)

Question one identifies the dominant economic features of the industry. The following identifies the economic features of the caviar and roe industry:

Table 12 Roe and caviar industry's dominant economic features

Market size	The world roe industry is worth in excess of €250 million. (Parker and Lilly, 2006)
Scope of competitiveness	The scope of competitiveness is generally global in the roe industry, with a small percentage of the market based on primarily regional niche products e.g. Bottarga, a salted mullet *Mugil cephalus* roe which is sometimes referred to as

	Sardinian Caviar.
Market growth rate	Market growth for caviar is at the mature stage, while substitute caviar products and roe products are at the growth stage.
Number of rivals and their relative size	The industry is very fragmented and is dispersed globally. The traditional caviar industry is dominated by larger companies due to strict regulation and scale of international trade and is focused on a small geographic area, while the roe and caviar substitute industry has many small companies, which are dispersed globally.
Integration.	Integration is a key factor of the industry with larger producers integrating backward into harvesting and integration forward into distribution (Anon, 2006b). As raw materials are in short supply, the potential for producers to integrate forwards has been identifies by the "sea change" document as a key success factor for future strategic development of the Irish sector.
Number of buyers.	There are large numbers of buyers for varying roe and caviar products. The caviar sector is growing Parker and Lilly 2006), as caviar is a luxury product consumption increases with increasing wealth.
Distribution channels.	Distribution channels are varied from the internet, global seafood shows, and wholesale distribution to the food service and retail distribution sectors to individual consumers.
Differentiation	There are low levels of differentiation with many 'me too' products. In general for authentic caviar products un processed roe may command a higher price than highly processed

	product as freshness is deemed to be of high value.
Ease of entry and exit	The market is relatively easily accessible with many global seafood shows in which to introduce products. Ireland also benefits by having a national strategy focused on growth and product development. Strategic liaison with global distribution firms with expertise in the global marketplace is a viable option. Barriers to entry in the caviar sector are high due to the low availability of raw material.
Profitability	Profitability is above average for the industry as demand is in excess of supply. As indicated in the market analysis sector, the retail value for fish protein of this nature can range in price from €75 to €1,182 per kg (Table 8). The increase of high quality natural products can only come from differentiation of product type i.e. harvesting previously un harvested roe and through aquaculture

In summary the indications of the above analysis are of a strong industry with moderate ease of entry, little differentiation, integration being an important feature of the industry and yielding above average profitability.

6.3.3 What is competition like and how strong are each of the competitive forces. (2)

To assess the competitive forces of the industry Michael Porters Five forces model shall be utilised (Porter, 1979). The five forces identified by Porter are;

1. ***The rivalry among competing sellers in the industry*** (Porter cited by Thomson and Strickland, 2003). Rivalry is relatively weak within the industry as demand for the products are high and profit margins are above par. Competitors are relatively well satisfied with their market share and sales growth. Price cuts are not used in the industry to attract new customers as demand exceeds supply.

2. **The potential entry of new competitors**. The potential for entry of new competitors is low due to the scarcity of roe products. Regulatory policies protect the caviar industry. While barriers of entry are low in the roe sector the scarcity of product is also a factor. Recent trade restrictions for caviar also deter potential new entrants. Access to raw material and forward integration from that point will give relative ease of entry.

3. **Competitive pressure from new products**. Pressure from rival products is low in the caviar sector. While there are many substitute products customers perceive these to be less satisfactory in terms of quality and prestige. In the roe sector pressure is slightly stronger in the salmon *Salmo salar/ Oncorhynchus nerka* sector with salmon roe cheaper and more available than other varieties, yet still yielding €75 per kilo.

4. **Competitive pressure stemming from supplier bargaining power**. Supplier bargaining power is high due to the scarcity of the raw material. Backward integration is a key factor for success within the industry.

5. **Competitive pressure stemming from buyer bargaining power.** Pressure from buyers is weak as demand for the product is in excess of supply. As this product commands prestige for its consumers price generally is not a concern when purchasing, with Beluga *Huso Huso* caviar commanding on average €1,200 per kg.

While rivalry among sellers is low and the industry commands higher than average profits, customers have a weak bargaining position and there are no good substitutes, success depends on the availability of raw material and integration forward to production.

6.3.4 What is causing the industry's competitive structure and business environment to change (3)

Each industry is subject to driving forces and these are the major reasons for industry change. These driving forces have been identified as being

- Scarcity of raw material due to over fishing and pollution.
- Globalisation of the market: both competition and consumer base are now global. This offers producers a greater audience for their product.
- Regulatory influences and government policy. Former bans on export of caviar from many countries due to environmental reasons created a greater demand for similar aquaculture based products. Fishing quotas are changed annually and this determines the available roe to market.
- Changing societal concerns and attitudes. Consumers are becoming more and more concerned with ethics and sustainability when purchasing.
- Changing economic environment leading to higher production costs in strong economies.
- Climatic changes and the future impact on fish population and habitats.

6.3.5 Which companies are in the strongest/weakest positions? (4)

Companies in the strongest position in the industry are those with backward integration (who have direct access to their raw materials). As demand for roe products is high and supply is limited, this is a key feature for success.

6.3.6 What strategic moves are rivals likely to make next (5)

The only identifiable growth areas within the industry are through aquaculture and previously un-harvested roe. Many new varieties of substitute caviar products are becoming available. These are based on other available roe like herring *Clupea harengus*, whitefish *Coregonus clupeaformis*, mullet *Mugil cephalus* and also substitutes using other non-fish bases like egg white and seaweed.

6.3.7 What are the key factors for competitive success (6)

Technical related key success factors include the product innovation capability, capability to use the internet for e-commerce activities and the technical capability and knowledge to keep production costs low.
Manufacturing key success factors include quality of manufacture, high labour productivity due to current high labour costs in this country and developing low cost product design which is a good strategic fit for this industry. The greatest success factor in this industry is the ability to access raw material and the forward integration to developing products to market. This has been highlighted by the "Sea Change" document, the seafood sector development strategy 2007 -2013. This type of strategy has been successful to date for the mussel industry. Cases include Bantry Bay Seafood and Fastnet Mussels Ltd.

Distribution related key success factors include developing a strong network and strategic alliance with other distributors, which compliment product range. Bord Iasciagh Maraigh (BIM) facilitates Irish seafood based companies with networking and product placement at global seafood showcases.
Marketing key success factors (Domegan, 2003) include the ability to identify the attributes and develop relevant marketing strategies and by offering customer guarantees and warranties on areas of food safety, ethics and sustainability.
Skills related key success factors include the ability to be creative in areas of product development and astute in quality management and the ability to get newly conceived products past research and development phase and into the market quickly.

6.3.8 Is the industry attractive and what is the prospect for above average profitability? (7)

Overall the industry is attractive with the greatest barrier to entry being the access to the raw material. Once this is achieved barriers are generally low. Growth of the industry will mainly be focused on product variety, harvesting previously unprocessed product and through aquaculture and also through the growth of novel caviar like products based on non-fish material. The prevailing driving force of low availability of the raw material for the industry, due to over fishing, climate change (Boelens, 2005) and pollution will be a determining factor in keeping supply low. In many incidences the processing of roe products is a by product of another process and can lead to greater economies for the company and a new avenue for earning revenue. Therefore given that Ireland has a high volume of un-harvested roe, there is strong potential for development of this industry.

6.4 Quantification of potential roe available to the market.

6.4.1 Introduction

One of the key objectives of this research is to identify what potential roe is available to the market. Currently Ireland exports herring *Clupea harengus* roe mainly to Japan, but little or no other roe is harvested (Industry survey).

In an endeavour to identify potential species from which to harvest roe, a probability calculation was conducted on the basis of figures published by who coordinate and promote marine research in the North Atlantic. ICES record catch levels by each of its members each year. For the purpose of the quantification only those species recording relative high catches were considered for the quantification (Url, 15).

6.4.2 Aquaculture sector

The strategy adapted differed slightly for the aquaculture industry. Initially in depth interviews were held with industry experts in the industry to determine the suitability of particular species for roe production. Through interview with Richard McNamara, managing director with Atlantic Fare who are involved in the salmon *Salmo salar/ Oncorhynchus nerka* and trout *Oncorhynchus mykiss* aquaculture sector, it was highlighted that these species need to be retained for a further year after prime harvesting time before roe is developed. This has an adverse effect on flesh quality and levels of natural oils retained. This coupled with the extra cost of retention deemed the potential for harvesting roe as strategically unwise and non-profitable. Concerns were also expressed as to the potential output being too low to be economical viable. Research is still underway to try and overcome these barriers.

A case study was then conducted on Arctic char to determine its suitability, as this species matures early, in some cases eighteen months to twenty months but more generally at two years of age.

Arctic char or Arctic char (*Salvelinus alpinus*) is both a fresh water and saltwater species in the salmonidae family, native to Arctic, sub Arctic and alpine lakes and coastal waters. No other freshwater fish is found as far north. In Britain and Ireland it is found only in deep, cold glacial lakes, mostly in Scotland and is at risk from acidification. It is at risk of extinction in Irish Lakes

Arctic char are closely related to both salmon *Salmo salar/ Oncorhynchus nerka* and trout *Oncorhynchus mykiss* and has many characteristics of both. Generally, whole market sized fish are between 2kg-2.3 kg. The flesh colour of char varies from a bright red to a pale pink.

Arctic char were first investigated in Canada for aquaculture because it was expected that they would have low optimum temperature requirements and would grow well at the cold water temperatures present in numerous areas of Canada.

The farming of arctic char is relatively new in Ireland and is proving successful. Cloonacool in County Sligo is home to one of Ireland's arctic char farms and was founded by Bill Carty and Mari Johnston, who are exclusively farming arctic char. They believe their approach is also unique with a focus on sustainability and eco-friendliness. No antibiotics, colourings or chemicals are added to the process.

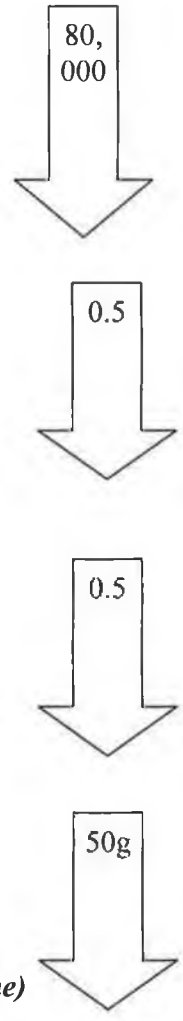
Through an in-depth interview with Bill Carty, the potential for harvesting the roe of the arctic char was investigated and he felt this would add extra income to the business with relatively small investment. Currently the company is paying for the disposal of roe and other waste matter. Roe is developed in the fish at eighteen months with a good balance between the quality of flesh and roe. The options for processing and potential markets were discussed. Greatest interest lay in three options:

1. Floating the roe in brine and exporting it to Japan, and possibly strategic alliance with an experienced exporter with particular market expertise.
2. The second option, which was felt to have strong market potential, was the presentation of arctic char caviar in 100g jars for the food service and retail sector.
3. Option three involved the smoking of arctic char roe and presenting it in 100g Jars for the global marketplace.

It was envisioned that the latter two products would originally be launched at major food exhibitions as a niche product. Creative marketing is considered to be vital in the developing a strong and sustainable image for the product (Domegan, 2003).

Bill Carty, manager of Clonacool Arctic Char estimated the potential output of roe and the following scenarios were uncovered.

80,000 fish are processed annually.



Ratio of male to female 1:1

Ratio of females with roe 1:1

Average weight of roe per fish= 50g.

(Erickson *et al.*, 1985)

80,000*0.5*0.5*50g = 1,000 kg (1 tonne)

Fig. 14 Potential Arctic char roe available to market

This indicates that there is potentially 1 tonne of roe available for harvest. Based on average market prices of salmon roe which achieves the lowest retail price of caviar type products, this indicates that the retail value of 1 tonne of arctic char roe is in the region of €75,000. In the wholesale sector, relative to salmon roe the potential value is 1000 –1500 Yen per 100g. This equates to a wholesale value of €61.20 per Kg, which amounts to added revenue of €61,200.

As a sustainable, ethically produced and organic product which is new to the market, the likelihood is that this product can achieve in excess of the price achieved for trout roe. Based on retail prices of trout roe the potential retail revenue is in excess of

€200,000. This is a considerable return with little extra output of resources. Currently the fish roe is discarded with other fish waste

6.4.3 Quantification for sea fisheries sector

In the sea fisheries sector the fish landings recorded by ICES for Ireland was used for developing a probability equation of the potential roe available to harvest. The recordings for 2005 were used, as these are the most up to date available (Table 13). The following assumptions are made based on advice received from experts in the marine biology sector.

1. Recorded catch have a male: female ratio of 1:1
2. Within the spawning season, which differs for each species, approximately 50% of female fish contain roe.
3. Spawning seasons were determined from the FishBase web site, a global information system containing facts and figures on various fish species. Fishbase was developed at the WorldFish Center in collaboration with the Food and Agriculture Organization of the United Nations (FAO) and many other partners, and with support from the European Commission
4. As during spawning the quality and quantity of eggs vary in accordance with the stage of development, the projection for roe content was estimated at a conservative 2% of body weight.

Table 13 Quantification of potential roe in the marine sector in Ireland

2005 ***Expressed in tonnes***	**Fish landings for Ireland**	% Of catch which are female	% Of females with roe	Spawning duration for species	Projected Fish containing roe. (By weight)	Estimated weight of roe.	Projected roe suitable for harvesting
Species		0.5	0.5	Ref fish stats			0.05
Angler(=Monk)	2921	1461	730	4 mths	292.10	5.84	2.92
Atlantic cod	1332	666	333	4 mths	111.00	2.22	1.11
Atlantic herring	29341	14671	7335	4 mths	2445.08	48.90	24.45
Atlantic horse Mackerel	33926	16963	8482	3mths	2120.38	42.41	21.20
Atlantic mackerel	44981	22491	11245	2 mths	1874.21	37.48	18.74
Blue whiting	69650	34825	17413	2mths	2902.08	58.04	29.02
European hake	1044	522	261	4mths	87.00	1.74	0.87
European plaice	477	239	119	5 mths	49.69	0.99	0.50
European sprat	4794	2397	1199	2 mths	199.75	4.00	2.00
Greater forkbeard	246	123	62	5mths	25.63	0.51	0.26
Haddock	2488	1244	622	4 mths	207.33	4.15	2.07
John dory	548	274	137	3 mths	34.25	0.69	0.34
Lemon sole	400	200	100	5 mths	41.67	0.83	0.42
Ling	926	463	232	3 mths	57.88	1.16	0.58
Pollack	756	378	189	3 mths	47.25	0.95	0.47
Saithe	562	281	141	3 mths	35.13	0.70	0.35
Turbot	215	108	54	5 mths	22.40	0.45	0.22
Whiting	6043	3022	1511	4 mths	503.58	10.07	5.04
Witch flounder	781	391	195	4 mths	65.08	1.30	0.65

Currently this roe is either being discarded at sea or sold on as fish waste. This roe can achieve great return if correctly harvested and processed. A small quantity of roe is currently sold, attached to fish filets. Table 13 gives an indication where potential for export and new product development lie, with in excess of 100 tonnes of roe available based on 2005 figures (Url, 15).

7 New Product proposal

7.1 Introduction

As indicated in chapter one the objective of this research is to develop fish roe products to concept stage. The stages to this are

1. Idea generation
2. Idea screening
3. Idea feasibility and
4. Concept development.

As a result of this analysis product concepts based on the Irish seafood industry shall be developed.

7.2 Idea generation

Ideas are generated through examination of the current trends in the market. Demand is generally stronger than supply and this will cause ease of entry for "me too" products (Booz *et al.*, 1982, Fuller, 1994, Kotler and Armstrong, 2005). These are products that are similar to products which already exist on the market. While new to the world products have first move advantage, they also incur greater expense to introduce to the market (Thomson and Strickland, 2003). As the five forces analysis (Porter, 1979) indicates that the potential entry into the market relies on the access to raw material, this gives Ireland a strong position to enter the market. New products should therefore be based on the availability of roe as depicted in the market analysis There are areas of high potential for roe development as indicated (Table 21, Table 22). These must be screened and potential products suggested for the more feasible options.

7.3 Idea screening

Very few new products are actually new to the world (Booz et al., 1982, Booz et al., 1976). It is estimated that, only 10 percent of all new products introduced over five years were truly innovative or new to the world. These are generally the most expensive to introduce from a marketing perspective, with benefits being achieved through first move advantage (Thomson and Strickland, 2003). Arctic char fits this

category. The Irish seafood aquaculture industry has a potential to enter the market with arctic char roe, which is a sustainable aquaculture product (Caprino *et al.*, 2008) One of the greatest benefits of this product is that availability is not seasonal and consumer supply can be continuous.

As previously discussed salmon and trout roe production, while yielding high margins, were deemed to be unsuitable as there was a trade off regarding flesh quality coupled with the added expense of retaining the fish for a further year to spawn.

Due to the aquaculture of cod *Gadus morhua* being in its infancy in Ireland, this will not be considered as a potential product. The potential retail value for Arctic char roe based on market value for trout roe is

Table 14 Potential market value of arctic char roe

Species	Projected roe available to harvest	Value based on similar products € per Kg	Retail value of projected available roe
Arctic char	1,000 kg	217.09	€217,090

In the marine sector there are many possibilities for future products. Quantification of roe in this sector cross-referenced with retail market prices for similar products will give an indication of potential revenue availability from un-processed roe. Due to the relatively small quantities of roe available, the logistics of harvesting and centralising processes will be extremely difficult. Instantly stripping the roe on production and placing it in brine or blast freezing it can overcome these difficulties. To develop a reasonable supply of roe to market it may be necessary to form various strategic alliances within the industry to facilitate forward integration. Reducing the layers to market will give the producers a greater margin and encourage key success factors as outlines by "Sea Change" – A Marine Knowledge, Research and Innovation Strategy for Ireland 2007-2013 (Anon, 2006b).

The following is a market indication of retail value of roe available from marine species, which are projected in excess of 1 tonne.

Table 15 Potential market value of marine roe (screened)

Species	**Projected roe available to harvest (Tonne)**	**Value based on similar products € per 100g**	**Retail value of projected available roe.**	
Angler	2.92	5.54	€161,768	As per salmon roe/ retail
Atlantic cod	1.11	3.50	€38,850	As per cod roe/ retail
Atlantic horse mackerel	21.20	13.75	€2,915,000	As per herring roe/retail
Atlantic mackerel	18.74	13.75	€2,576,750	As per herring roe/retail
Blue whiting	29.02	7.89	€2,289,678	As per wholesale Pollock roe
European hake	0.87	2.607	€22,681	Japan wholesale
Haddock	2.07	3.50	€72,450	As per cod roe retail
Whiting	5.04	7.89	€397,656	As per wholesale Pollock roe

Monkfish roe differs in appearance and structure to caviar style roe. It has the appearance of ribbons and a much smoother appearance. This product has been identified on the food service market as an Asian style soup and also as a monkfish pate (personal observation). As these products are new to the retail market and require high level processing they may be expensive to introduce.

While the quantities of mackerel *Scomber scombrus* roe are significant for processing, there appears to be concerns in the market at the quality and quantity of recent catches in Canada. If these fears are materialised strict quotas may be enforced to protect the species (MacKenzie, 2002). In the event of a stable environment this may be an extremely viable option yielding in excess of €5 million for the Irish seafood market.

These projections are based on similar herring *Clupea harengus* products for which a market exists. The mackerel *Scomber scombrus* roe sector is less developed and will require greater resources.

Another highlight of the financial projections is the potential €2.6 million available through the processing of whiting *Merlangius merlangus* roe. This projection is based on frozen pollock roe imported by Japan. Korea also import smaller amounts of Pollock roe but pay in excess of 33% on the Japanese wholesale price. With regard to the potential for blue whiting *Micromesistius poutassou* considerable marketing and industry restructuring may be required to raise the profile of this species, as the majority of current catch is directed to the processing of fish meal. Hake *Merluccius merluccius*, haddock *Melanogrammus aeglefinus* and whiting *Merlangius merlangus* roe may be combined to make a taramasalata style product. Alternatively these products may be frozen or brined and exported in their natural form.

7.4 Feasibility

To determine the feasibility of any potential project it first vital to understand the difficulties that limit the likelihood of success. Lynch (2000) identifies three areas in which a proposal or option may lack feasibility. These are:

- Internal factors such as skills, resources and culture of an organisation
- External factors, competitive, supplier and customer reaction.
- And lack of commitment from the main stakeholders i.e. management and employees.

7.4.1 Internal feasibility

Areas of concern with internal feasibility include capital investment, projection of profits, capital required and increased liabilities which may occur as a result. Technical concerns include new skills, technology requirements and how new products are to be developed. Marketing concerns include the potential to complete the new product process and bring it to market. (Cooper, 2006). Under the "Sea Change" strategy funding is available for the development of aquaculture and the fisheries industry, with strong emphasis on the development of functional foods. As determined in the industry analysis conducted, profit is above average in the roe industry and demand is strong.

The level of processing required will greatly determine the cost of production, skills required and the technology necessary. As outlined in chapter three there are many possibilities for processing fish roe. There are two, which must be highlighted from a point of view of novelty i.e. high-pressure processing and low frequency radio wave. While these may exude many benefits the cost of employment is far in excess of its benefits. Coupled with this, the high cost of human capital in Ireland deems these unfeasible. Chilling, freezing and salting are less technologically advanced and more suited to a small and mid scale operation. Pasteurising may be a strong contender especially if a strategic alliance is developed with a company skilled in this area. It is possible to outsource this activity outside of Ireland, to a country reputable for high level processing which has low production costs.

7.4.2 External feasibility

Areas of concern with external feasibility include customer's response, competitor's reaction, pressure from suppliers and government regulation.

Customers will respond favourably to new product ranges and diversity (Fuller, 1994). Demand is strong globally and will be increasingly so for sustainable and ethically produced products.

Competitor pressure will be relatively weak as rivalry within the industry is not strong due to high demand. Roe availability being a key success factor within the industry is also a strong incentive to enter the market where roe is available.

Currently there are strict guidelines regarding food production and also fish quotas in the marine sector, which will determine the potential roe available to the Irish market. As identified in figure 2 fish quotas may change each year and this may induce a feasibility concern. In the event of building an industry, degradation of quotas in future years at short notice may not allow for exit or change strategies to be timely adopted. Future restrictions on marine roe harvesting may be adopted in an endeavour to protect brood stock of future generations. Placing a high market value on marine fish roe may lead to increased exploitation of natural stocks and destruction of natural habitats. Coupled with this are the concerns of global warming and the changing habitats of fish species i.e. cold-water species may have to move more northerly as oceans warm. Any future development must take into consideration preservation of natural habitats while satisfying consumer trends, while achieving long term profits.

7.4.3 Employee and management commitment

Employee and management commitment is vital in any process. Motivation and commitment are vital to success. In the aquaculture sector production units are relatively small and have fewer layers of distribution. In the case of The Cloonacool arctic char farm human capital is currently under utilised and commitment is strong. Without adding to labour costs there is potential for further revenue through harvesting arctic char roe. Processing may be kept to a minimum by choosing a traditional method of preservation i.e. smoking, freezing or salting. From a management and employee perspective this is a feasible project.

There are many more restrictions in the marine sector due to the multi layers and diversity of distribution. Also the strong culture developed in the fisheries is an inhibitor. The "Sea change" strategy (Anon, 2006b) proposes to address this by concentrating on 'improving the management, competitiveness, structures and profitability across all sectors of the industry including sea fishing', and also through achieving 'structural adjustment in the processing sector to enhance coordination nationally of processing and marketing of uniformly high quality products'. Another focus of the strategy which may support the development of a roe industry is 'the potential for innovation, product development and value enhancement of primary aquaculture production and shellfish, whitefish and pelagic fish landed into Ireland' (Anon, 2006b). The key to the success of a potential roe industry is the co-ordination of resources to ensure a maximum yield and a coordinated marketing exercise.

7.5 Concept development

One of the objectives of this research is to suggest innovative products, which will add value to the seafood market, generate a financial return for investors and fulfil the requirements of the identified market gaps. As indicated in the market analysis there is strong demand for roe products and this demand is global. As outlined in the previous section the production of roe products based on arctic char is feasible. Considerations, which must be undertaken in the decision of product type, are market destination and processing method.

As outlined in the "Sea Change" strategy forward integration is considered to be a key success factor (KSF) for future seafood producers in Ireland. Considering the technology requirements for such processing, it is advisable to minimise the

technology requirements and labour input to achieve higher margins. Based on this the recommended technologies to be adopted are salting, smoking, modified atmosphere packaging and freezing. In a recent report by BIM, the benefits of smart packaging are outlined (Gormley, 2006). This can play a key role in determining the end product. With regard to ethical consumerism, there are many concerns prior to product development. With media focus on depletion of natural stocks giving rise to ethical concerns and a risk of lowering demand, many companies have re directed their market focus. Marketing strategies based on sustainability and ethics are becoming more abundant (Shaw and Shiu, 2003). Products based on fish roe must appear to be ethical and sustainable. As projections are based on raw material currently being un processed, concerns surrounding depleting stock are dealt with through tight fish quotas. Careful monitoring must ensure that the proportion of fish to fish roe is reasonable and that "bi catch" is not being increased to meet roe demands.
Consumer trends should be taken into consideration when developing new products. The trends, which proposed roe products could satisfy, are

- Life on the Go': consumers are looking for solutions to their busy life schedules and products and services that remove complexity and save time become essential elements in consumers' lives. Caviar is an instant party food or hors d'oeuvre and requires no further preparation.
- 'Living life to the full': consumers want experiences that help them get the most out of life. Consumers are experimenting with new combinations and fusions are gaining the attentions of consumers seeking these new experiences. Artic char roe will satisfy the palate of people looking for new tastes and variety. There is also a potential to develop spiced roe products to suit the desire for fusion food.
- 'Making a difference': Demand is rising for products that have reduced their impact on the environment or that offer a sustainable alternative. This trend was emphasised at the Brussels Seafood Show 2007 with many companies claiming ethical and sustainable benefits to their products. Cloonacool arctic char is produced in an environmentally friendly manner and does not deplete natural stock or effect the environment in an adverse manner. These may be the basis for a positive

marketing strategy (Holland *et al.*, 1991, Bogue, 2000, Bogue and Sorenson, 2005, Gray *et al.*, 2003).

All five macro trends identified by Baines (2006) may easily be adapted to any fish roe product. These include Healthier and lighter, Flavour sensation, Snacking and Grazing, Food as enjoyment, and Health Fads. Provenance in the case of Cloonacool arctic char is strong as the current brand strongly identifies with the natural surroundings and has a strong emphasis on ethical production and sustainability. The micro trends also identified by Baines (2006) can also be easily incorporated into design of new products.

Holland (1991) and Rogers (1990) highlight the benefits of the macro trend functional foods. Fish roe with its high vitamin b12 and omega 3 oils, which are beneficial to health (Engler *et al.*, 1999, Feart et al., 2008, Hall et al., 2008, Dangardt *et al.*, 2008,), may be marketed as a functional food. The full market potential for functional foods can only be achieved by the development of market-oriented products (Bogue, 2000, Bogue and Sorenson, 2005, Gray *et al.*, 2003)

7.5.1 Concept proposal

Roe products, which may add value to the Irish seafood market, are proposed taking into consideration market conditions. Arctic char roe has high potential at satisfying current market conditions.

Three options are outlined for the future development of this novel food item.

1. The first of these is arctic char caviar. This may be produced firstly by marinating the roe in 2% brine, and presenting it in 100g jars. This product is focused at the retail market. The product if developed at Cloonacool could carry the brand already developed for its other Arctic char products greatly increasing the benefits of economies of scale and satisfying the market trend towards provenance (Baines, 2006). The main market for this type of product is in Europe and North America. This product could be introduced to the market and tested through entering the new product competition at the major seafood exhibitions and through the Festival of Fine Food in London. Research may also be carried out into the possibility of pasteurisation. Trout *Oncorhynchus mykiss* caviar produced in this way has proven successful

(Miettinen *et al.,* 2005). This caviar may be spiced or flavoured taking into consideration key macro and micro trends.

2. Alternate to this proposal is the production of smoked arctic char roe. This must also be brined prior to cold smoking, as the smoke is used as a flavour in this instance as opposed to a preservative. This product may be suitable for the Asian market and simply presented in MAP packaging, or alternately presented in 100g jars for the retail market in Europe and North America.
3. A simpler and more natural presentation for the Japanese market may involve floating the entire lobes in brine in bulk packaging. Processors prefer to buy roe in this manner as they have very high standards of processing, which is especially vital as the majority of these products as eaten as sushi.

For entering the Japanese market it is highly recommended to form a strategic alliance initially with an agent currently exporting to Japan. This can greatly reduce the initial time taken to enter the market. JETRO (Japan External trade organisation) assist companies by disseminating regulations, requirements and relevant information on the Japanese market.

Due to the inconsistent nature of the supply of marine fish roe it would not be feasible to build a processing industry in this country based on one variety of fish roe alone. Three viable options for dealing with this invariable are:

1. The processing of taramasalata, a flavoured fish paste based on various roe varieties,
2. Floating the roe in brine instantly at initial processing phase and exporting it in this manner to Asia.
3. The third option, similar to the latter but freezing the roe lobes instead of brining them. This will allow a build up of roe, until an amount is reached that is viable to export.

Overall projected roe products have the potential to add a total of €8.5 million to the Irish Seafood market.

In summary the Key success factors are

- Access to raw material
- Consideration to ethical and sustainable concerns
- Developing products, which are not "processing intensive".
- Strategic alliance with experienced exporters to destination markets.

- Forward integration of primary producers to capitalise on profits.
- The development of a co-op situation within the industry to overcome fragmentation and difficulties with logistics of getting roe to market.

8 Conclusions and recommendations

8.1 Introduction

This research was undertaken to highlight the Market potential for fish roe products in the Irish seafood industry. Research outputs of this project will be identified and conclusions drawn based on those outputs. Recommendations will be offered for future research and development within this segment of the industry.

8.2 Research outputs

The research outputs of this work are as follows:

1. Analyses the current driving forces in the Irish Seafood industry and the potential effect this has on the future market.
2. Concise market analysis for potential entrants to the roe market. Major markets for roe products are highlighted, as are various roe products available on the global market.
3. Quantification of potential roe availability to the Irish seafood market. This was based on a probability calculation conducted on the figures published by ICES for fish landings (2005) and a case study on an aquaculture unit focused on arctic char production. For the purpose of the quantification only those species in the marine sector recording relative high catches were considered for the quantification (Url, 15).
4. The results of a "5 force analysis" of the roe industry, identifying barriers to entry of the roe market, threat of new products, pressure stemming from both buyers and suppliers and the strength of competitive rivalry.
5. Product concepts were developed which will add value to the Irish seafood market.
6. Based on reasonable assumptions within the industry, projections of potential revenue available were conducted, outlining a growth in revenue in excess of €8.5 million.
7. A Case study of Cloonacool arctic char was conducted.

8. An audit was conducted of Irish seafood producers to determine level of current and past activity of roe production by Irish seafood processors.
9. An identification of consumer trends in relation to food products and how these may effect future development of new products.

8.3 Conclusions drawn

Irish seafood is a vital contributor to the Irish economy with total Irish sales in seafood in 2006 amounted to €724.6 million. Growth in the industry in light of tightening quotas will depend largely on aquaculture and the development of value added products for both marine and farmed stock. Relative success has been achieved by the mussel industry in forward integration, through the development of many quality products. The key trends highlighted by BIM in the seafood market are relative buoyant markets, tight quota restrictions, reduced raw material supplies and higher operating costs, with processing and labour becoming less competitive relative to global markets.

While aquaculture has been identified as an area of growth the following driving forces have been identified. Pressure on the industry stems from low-cost selling by salmon *Salmo salar/ Oncorhynchus nerka* producers in Chile and Norway i.e. fish dumping, reported difficulties with disease, ethical consumerism, concerns regarding sustainability and the disposal of waste material from the fish processing. The development of roe products can increase revenue in both marine and aquaculture sectors.

The world roe industry is strong and vibrant with a wide range of roe products available in the global market place. While caviar is embedded in history and generates high revenue for those involved in the industry, restrictions for growth in the industry lie in the availability of raw material. To meet the market shortfall and attempt too capitalise on potential above par profits, many imitation products have come to the market place. Other traditional uses of fish roe include fish roe pastes, dried fish roe and also salted fish roe lobes. The driving forces within the world caviar industry, which have been identified, may result in the growing demand for substitute

products and the rise in ethical consumerism, the depletion of natural stocks and concerns regarding pollution.

The key success factors within the industry lie in the availability of roe and the potential through forward integration to develop new innovative products, while keeping careful consideration to minimising processing and labour costs. Strategic alliance with exporters who have expertise in destination markets chosen is also vital in an endeavour to reduce time delays associated with setting up as a reputable exporter.

Potential roe of various species to the value of €8.5 million is available annually for harvesting. This roe may be processed and packaged to suit the destination market. Co-operative alliance may be required to develop a volume sufficient to satisfy export needs, as the supply is variable and fragmented.

Produce supply from aquaculture is more stable and therefore a more feasible option. Arctic char is a relatively new aquaculture species in Ireland and there is strong potential for the production of differentiated arctic char caviar, which has the potential to add in excess of €200,000 revenue the individual production unit at Cloonacool Arctic Char. The same volume of roe targeted at the Japanese wholesale market has the potential to generate revenue in excess of €60,000.

With the support of BIM and Enterprise Ireland to consolidate expertise within the industry, there is potential for further sustainable development, increasing revenue through value added products.

Un-harvested roe from fish landed to Irish ports and the aquaculture industry have the potential to assist in achieving valuable revenue and increased growth for the industry.

8.4 Recommendations

To realise the market potential for fish roe products within the Irish seafood industry the following is recommended

- Develop innovative differentiated products based on aquaculture products in Ireland, with specific emphasis on arctic char.
- Develop market specific products from marine based roe, which involve low levels of processing.

- To overcome fragmentation in the industry the development of a co-op based strategy to market Irish produce is vital. This will overcome difficulties individual producers experience with low volume.

8.5 Suggestions for further research.

While the key focus of this research is to identify market potential for fish roe products in the Irish seafood industry other areas of potential future research have been identified. These areas are as follows,

- Development of fish roe products to market launch stage of NPD.
- The execution of a waste management audit to include a breakdown of material disposed and a specific costing regarding disposal.
- Investigate the possibility of treating fish roe with high-pressure processing and low frequency radio waves.

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Appendix – Questionnaire

1. How many employees are employed by your company
   click here to enter result

2. Is your company actively involved in Research and development of new products

   ☐Yes ☐No

3. What methods of production are you currently utilising?

☐ Canning/ bottling
☐ Brining
☐ Chilling
☐ Freezing
☐ High pressure processing
☐ Smoking
☐ Other (please type answer in shaded area)

4. Is your company actively exporting?
   ☐Yes ☐No

5. To which region is your company exporting

☐ USA
☐ Japan
☐ EU
☐ Other (please state)
☐ Not applicable

6. Is your company currently involved in Roe production

   ☐Yes ☐No

   If yes please state roe type used (type answer in shaded area)

7. Have you produced roe products in the past?

   ☐Yes ☐No

   If yes please state roe type used (type answer in shaded area)

8. Are you interested in producing roe products in the future?
   ☐Yes ☐No

9. Are you interested in receiving current research findings in the area of Roe product development
   ☐Yes ☐No